THE TRACTION ENGINE CATECHISM

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THE TRACTION ENGINE CATECHISM

A HAND BOOK OF PRACTICAL INFORMATION FOR THE FARM ENGINEER AND THRESHERMAN

COMPILED FROM REGULAR ISSUES OF

THE THRESHERMEN'S REVIEW

WITH ADDITIONS OF REFERENCE TABLES

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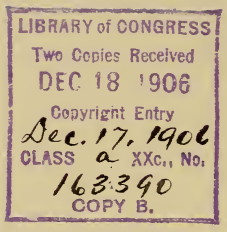

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PREFACE.

Several years ago The Threshermen's Review established a department of questions and answers; a department devoted to the printing of plain questions from threshermen, relating to the business of traction engine operation, and of threshing.

This met with immediate and unqualified favor among threshermen, and every issue of The Threshermen's Review since has contained a goodly number of bona fide questions from threshermen and our answers thereto.

Then came numerous suggestions that these questions and answers be assembled in book form for convenient reference; and these suggestions finally resolved themselves into so insistent a demand that the thing be done that we decided to comply with it. Hence this book.

This work makes no pretentions of completeness; of covering all the questions that may arise in traction engine practice. It is just a compendium of the matter printed in our department devoted to questions and answers since its establishment. It therefore has no "plot"; no attempt has been made to make of it a complete handbook of the traction engine. It is simply what its title indicates: a catechism of the traction engine, with this difference from other works of the kind, that the questions

dealt with are those that have actually been asked by working threshermen who have met the problems indicated and have brought them to this paper for solution.

In conclusion, we wish to thank our readers for their many expressions of appreciation of this department; and we hope that this condensation of it will be of some service to them in solving many of the problems that confront them in the operation of their machinery.

THE THRESHERMEN'S REVIEW.

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Traction Engine Catechism.

CHAPTER I.

THE ENGINE.

Q.—What is an engine?

A.—The word engine is used sometimes to indicate contrivances that our correspondent would probably not recognize as coming under this classification. For instance, a large gun might be termed an engine of destruction; a torpedo boat or even a battleship might also be so designated. The Standard Dictionary is authority for the foregoing; also that any agency or instrumentality devised or designedly employed may be so termed. As "An engine of oppression." In mechanics, an engine is a machine for converting some motive energy, usually heat, into work. This is an engine as generally meant; but the term is also applied to elaborate and complex machines for doing intricate and superior work.

Q.—What is the limit of piston speed to which a traction engine should be run?

A.—The rotative speed of a traction engine will keep it below the limit. A 12-inch stroke engine running 300 revolutions per minute has a piston speed of 600 feet per minute. Locomotives run as high as 1,000 feet, and engines in torpedo boats as high as 1,200 feet per minute.

Q.—How much of the heat of coal is gotten into the steam?

A.—Authorities on the subject tell us that about 77 % of the heat of coal is given to the steam.

Q.—I bought a double cylinder simple engine this fall. I understood when I bought it that it had no dead center. I find that it has places where it will not start with the throttle wide open and no load. The agent who sold me the engine tells me I have to throw the reverse lever down toward the end of the quadrant to start it. Now, the engine will run hooked up in the notches toward the center of the quadrant, and sometimes it will start there. Why does it not start there every time? Surely there must be something wrong with the engine or it must have a dead center, although the catalogue claims the engine has no dead center.

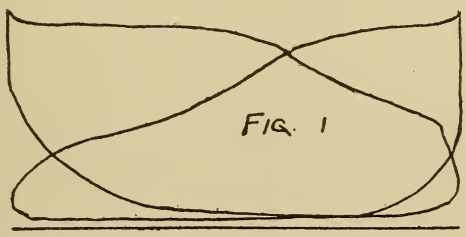
A.—It is true that a double engine with its cranks set at 90° has no dead center, as only one crank can be on the dead point at a time. While one crank is on the center the other is in position to do business if steam is turned into the cylinder, but if the reverse

lever is in the center notch it cannot start, and even if the reverse lever is thrown far enough ahead so that the valve cuts off the steam at one-half stroke, the engine cannot move when the cranks are set as mentioned in the foregoing. However, the engine will start with the valve gear set at one-half cut-off, providing the one crank is set, say at one-eighth or one-fourth stroke to begin with.

The correct way to start a double engine is to always have the reverse lever thrown well down to the end of the quadrant, and when the engine is started hook it up to the point at which you wish it to run. This is the way locomotives are started, and a double traction engine is built on the same general lines.

Q.—Enclosed find a card taken from my engine. Please tell me what is wrong with it, or what is wrong with my engine. I set the valve with the same lead on each end, but the diagram on the card shows that one end is different from the other. Please tell me why this is. The engine has a link reverse and seems to be in good condition.

A.—We have made a cut of the diagram, shown in Fig. 1. The cause for one end being larger than



the other is that the cut-off is not equal. It happens

with a valve gear of this nature that when the lead is equal the cut-off is unequal. To get the cut-off equal the lead must needs be unequal. An unequal lead will be more desirable than will be the unequal cut-off, for it happens that the piston is practically standing still when the valve is opening the port, so it cannot effect the engine as much as the unequal cut-off as shown in Fig 1. Shift your valve so that it will make a card which will be equal on each end. Then if you will send it to us we will make a cut from it and publish it.

The reason why an engine with an ordinary valve gear cannot have an equal lead and an equal cut-off is due to a peculiarity in the travel of the connecting rod; writers on this subject call it "The angularity of

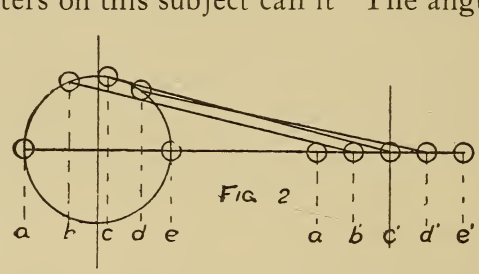


FIG. 2

the connecting rod"—in consequence of which the piston travels faster at one end of the cylinder than at the other. Fig. 2 shows the unequal positions of the crank pin, *a, b, c, d* and *e,* while the positions of the crosshead pin are equal; *a,' b,' c,' d'* and *e.'* In Fig. 3 the positions of the crank pin are equal, while the positions of the crosshead pin are unequal. In Fig. 2 the crosshead ,*c',* is on the center line while the position of the crank pin, *c,* is off the center line. One

can readily see that the distance from *a* to *c* is greater than from *c* to *e*, while from *a'* to *c'* is the same as from *c'* to *e'*. Since the eccentric is carried on the shaft and since the motion of the shaft is uniform,

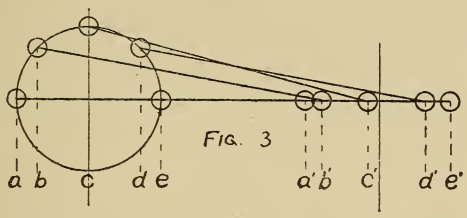


FIG. 3

due to the balance wheel and since it takes as much time for the crank pin to travel from *a* to *c* and from *c* to *e* in Fig. 3, the piston will travel slower from *a'* to *c'* than from *c'* to *e'*. This accounts for the unevenness of the card when the valve is set with equal lead.

This can be corrected in an engine with a rocker arm instead of a valve rod guide when the rocker arm is set to move farther on one side of the center than the other. This is done in locomotive practice.

Q.—Would it be advisable or good to change the position of the piston in an engine after the engine had been run for four years; the piston and rings being run in the same position all that time?

2.—How can a click be stopped in the cylinder, caused, I think, by wear of the piston rings?

A.—If a piston is properly made the rings will travel over the counter bore of the cylinder. If they do not they will wear a shoulder in the cylinder. In this case the piston will have to be taken out and the shoulder filed off before it is safe to change the position of the piston.

2.—If the rings are loose in the piston, which they likely are if they click, the only remedy is to get new rings which are wider and fill up the grooves.

Q.—Will some one tell me why an engine should not be reversed without shutting off steam? One expert machine agent called me down for doing it, and said it injured the valve to slide it with the lever when under pressure. I presume I am dense, but I can't see what difference it makes to the valve, to draw it with lever or eccentric. I know it gives the gearing a bad jar to throw the reverse quickly and I would like to know any other reasons. My engine is an old Pitts, used eighteen falls. Has a screw throttle that is slow to use, consequently it is always handled with the reverse lever. The valve has not been repaired and have put in no new rings nor no new gears. It works good and steams easily.

A.—If an engine is well designed, reversing it without shutting off the steam will not hurt it in any respect. In fact, there is more harm to come from reversing with the throttle closed when engine is running at a high speed, for when an engine is running in an opposite direction to which the valve gear is set the engine is turned into a pump and it pumps air from the stack through the exhaust nozzle into the boiler. This can be done on a locomotive coasting down hill. However, there are release valves on the steam ports which prevent this on a locomotive; but on a traction engine it can only be done when the engine is pulled by another engine or by running the

engine to a very high speed and then suddenly reversing it. If the flywheel is very heavy it is more effective than if it is light. This we have said will pump air into the boiler; but if the engine is suddenly reversed while the engine is at a high speed and while the throttle is shut, the air cannot go into the boiler, but is pumped into the steam pipe against the throttle, and if enough power is put to the flywheel of the engine something will burst; but if the throttle is left open the piston never has any more pressure than is in the boiler to pump against and that should not hurt it.

Q.—Which will use more fuel and water, a 12 h. p. engine running at 225 revolutions per minute, or the same engine at 250, the load remaining the same?

A.—This depends on the load. If the engine is overloaded the higher speed is the better, but if the load is too small for the engine the slower speed will be the better.

Q.—I have a Russell 14 h. p. compound engine and when I pull the reverse lever open it pounds hard, and when I put it near center notch it does not pound so badly but will not furnish power enough. I admit steam in the low pressure cylinder early and that helps, but causes back pressure. What would you advise to do to help the case?

A.—From your description we are inclined to believe that your engine is too small for the work you are doing. An engine with an expansion gear, as the Russell, should not be worked with the reverse

lever down in the end notch, as this notch is only for convenience in starting or pulling through a hard place when occasion demands. In this notch the valve cuts off the steam at about three-fourths of the stroke and at this point the compression is low and does not afford sufficient cushion for constant use. The engine should be large enough for the work, so that it can be hooked up to say one-half stroke. This would be late enough for a compound engine. A simple engine should be hooked up to one-third or one-fourth cut-off. If you are not ready to purchase a new engine, the best remedy we can offer you is to carry as high pressure as your boiler will safely permit and hook your valve gear up as far as possible, that is to run the engine with the reverse lever as close to the center of the quadrant as possible.

Q.—Which is the most economical point of cut-off at which to run an engine? I notice that some engines have no means of hooking up the valve gear. I presume they are set at the most economical point, and would like to know where that point is, as my engine has a great range of adjustment on the reverse quadrant. Can an engine be hooked up too far for economy, and if so, what is the limit?

A.—An automatic single valve engine is generally supposed to be cut-off at one-fourth of the stroke. It would hardly be practical to try to run a traction throttling engine at that cut-off, as the load is so irregular that the cut-off has to be set late enough to take care of the maximum load. The traction engines with

a fixed cut-off are set to cut off at about one-half stroke. The best place to run the valve gear on a traction engine is to hook it up as far as possible. The engines are very seldom large enough for the work to get the best economy, so there is no danger of hooking them up too far. The best way to find the place for the reverse lever is, after the engine is at work to hook it up until the speed slacks a little, then move it one notch forward. This is generally enough to take care of the maximum loads. However, it should never be hooked up closer than to one-fourth cut-off.

Q.—In putting on a new engine bed on an engine would you make rigid fastening on pillow blocks when the boiler is cold or would you steam up to about 75 lbs.—working pressure 150 lbs.—to divide the strain on the engine bed equally between expansion and contraction of the boiler, which apparently cracked the lower side of guide of old bed?

2.—The new bed comes with bearing for main shaft babbitted. Opposite bearing has never been opened and seems to be in good order. Would you put it up without rebabbitting both new and old bearings?

3.—What h. p. will a 6½ x 10, 10-inch stroke tandem compound engine develop, running 230 revolutions per minute, at 150 lbs. pressure?

A.—On some engines there is a slip joint where the cylinder is bolted to the boiler which allows the boiler to expand and contract without exerting an

undue strain on the castings; but if the cylinder and bed or frame are bolted rigidly to the boiler it certainly would help matters to bolt it up at a medium temperature of the boiler and thus reduce the danger of breaking the frame.

The temperature of the boiler at 150 lbs. gauge pressure is about 355° F. Say the average temperature of the atmosphere is 45°, this would make the average temperature of the boiler 200°. Steam at atmospheric pressure, or just before it shows on the steam gauge, is 212°; so you see a medium temperature would be at about this point. As there are only about 50° between 75 and 150lbs. pressure, 75 lbs. would be a medium pressure but would not be a medium temperature.

2.—The main box in the engine frame is square with the cylinder and in the factory the shaft is bolted fast by means of the main bearing cap, so that after the cylinder and frame are bolted to the boiler the shaft is rigidly held in place and the outer bearing is babbitted last. It may be possible that the outer bearing will be exactly in position. This can be found out by close examination, and if it is not exactly in position the babbitt should be cut out and replaced after the cylinder and frame are bolted to the boiler, and shaft is securely held by the cap. To insure the shaft being held properly, the liners should be taken out from between the cap and box.

3.—The nominal h. p. as given by the manufacturers is 20 and the maximum brake h. p. is 49.

Q.—Do you think that the oil that runs down over

the side of boiler will do any harm if not removed?

2.—We do not use our governor when sawing and I notice that the engine will run faster when hooked up than it will when the reverse is in the last notch. This is when engine is not working any and just enough steam admited to run, say, 125 revolutions. (Woolff reverse). Can you tell me why this is?

A.—The only harm the oil on the boiler does is to its looks.

2.—Your engine running without the governor controlling it and using the throttle to control the engine will run faster cutting off early than late, for the reason that the steam works on expansion to a higher degree when cutting off early, and thus getting more value out of the steam. This is a proof that "hooking up" helps the economy. On a cross compound engine, when it is arranged so that it can be run either simple or compound, and when a certain amount of steam is admitted by the throttle in both cases, the engine will run faster running compound than it will running simple with the same amount of steam. This is a proof that a compound engine is more economical than a simple engine as it shows that there is more value gotten out of the steam in running compound.

Q.—Does hammering on a check valve or an injector do any good in starting it when it is slow in taking water?

A.—Hammering on an injector will do no good in helping the injector to take the water. It sometimes happens that when an automatic injector runs

at the overflow a little tap will do some good. Hammering on a check valve can do no good in starting an injector.

Q.—My engine is a 22 h. p. and my separator is a 40 x 62 with a blower of a standard kind, feeder and weigher. Now in dry grain the engine handles it with perfect ease and yet uses up from seven to eight twelve-barrel tanks in a day of about 12 hours. There is no leak of water and hardly any of steam except the regular use. The valve is set perfect. I took the cylinder head off to see if the rings leaked, but they leaked just a little on one side of the piston head, but it was so little I don't think it would hurt that much. The valve don't leak either as far as I could judge. Last year we used only three to four and a half tanks a day and the grain was all wet and tough, so the engine had to work harder. This year it was easier, yet she uses more water.

A.—If the piston and valve are reasonably tight and the valve is set correctly, the trouble is evidently in the running of the engine. Perhaps you hooked up the valve gear last year and this year you run the valve at full stroke. This would make some difference in the water consumption. If your boiler foams this also would cause it to take more water. It may be to your advantage to have a good machinist look over your engine, if possible a representative of the factory at which it was built. It may be that there is something out of place which you do not notice. There is something radically wrong when an engine

takes twice as much water as it did a year ago.

Q.—What is the difference in the economy of different classes of engine? Why would it not pay to have a higher grade engine for the traction engine, say a Corliss and condensing engine?

A.—The additional first cost of the engine is one thing in the way, although there is room for some advancement along this line. An automatic cut-off engine for the thresherman may not be far off; but as for a Corliss and condensing engine for traction work, this may never come, especially the latter. The water consumption of a single valve simple, non-condensing engine is from 30 to 33 lbs. per hour per h. p.; a compound single valve non-condensing engine is from 22 to 25 lbs.; a compound single valve condensing from 14 to 16 lbs.; a simple Corliss non-condensing engine, from 27 to 30 lbs.; a compound Corliss condensing engine, from 12 to 15 lbs.; a triple expansion Corliss condensing engine from 10 to 14 lbs.; steam turbine, high grade, 15 lbs.

Q.—I have a complete outfit consisting of a 25 h. p. engine, 42 x 66 separator, with self feeder, blower and weigher. I would like the opinion of The Review in regard to the engine. It has a cylinder 10 inches in diameter and 12-inch stroke, with a Woolff reverse gear. It don't seem to have as much power as it should and pounds terribly when doing hard work, especially when the relief exhaust is closed. When the reverse lever is in the last notch the valve only opens the ports about three-fourths

of their width, and cuts off at about two-thirds stroke, while the lead is nearly one-eighth inch.

Don't you think there is too much back pressure due to compression and lead, which also pushes the valve off its seat and lets it come back with a pound?

Would not a new eccentric strap that has the connection for the eccentric rod farther up towards the block give the valve more throw and less lead?

A.—A valve need not open its port full to admit steam, as the port is made wide enough to let the exhaust escape at a low pressure, say, almost atmospheric pressure, and at this pressure the volume is much greater than at boiler pressure. In the ordinary size traction engine one-fourth of an inch opening for the live steam into the cylinder will be as efficient as three-fourths opening to let the exhaust steam out of the cylinder. On investigation you will find that when the valve gear is hooked up so that there is but a small port opening to admit live steam, the port is always opened wide for the exhaust steam. One-eighth of an inch is not far from the right amount of lead for this size engine. One-thirty-second of an inch less might be better, but in later years engines have been given more lead than before the engine indicator was in use by traction engine builders. It will be interesting to you to find out how much the piston travels while the lead is effected, in other words move the engine in the direction in which it runs until the valve is just ready to open, make a mark on the crosshead shoe and guide, then move the en-

gine to the end of its travel and you will be surprised to see how little the piston moves to accomplish the lead. In this position of the engine's travel, the valve is moving its fastest and the piston is moving its slowest, and this is why a little excessive lead is not as detrimental as one would suppose at first glance. At all events we do not think it would pay you to get a new eccentric strap to reduce the lead.

Your engine does not pound from excessive compression. A lack of compression would be more apt to cause a pound. When the valve gear is hooked up to effect an early cut-off, the compression is higher and you will find this is where the engine runs the smoothest. Your best plan would be to hook the valve gear up as far as possible, to not only get a quiet, but also an economical engine. Any looseness about the boxes always makes more noise when the engine is cutting off late in the strokes.

Q.—In a crosshead pump, such as is used on most traction engines, where one valve works over the other, what is the best thing to use to reduce the lift of the valves and how to hold it in place?

2.—What is the proper lift of pump valves?

3.—How is the diameter of round valve seats measured; in the small opening at the bottom, or at the top?

4.—What is the best way to pack a piston rod and what is the best packing to use?

5.—What is the best packing for a crosshead pump?

6.—In an old engine on which the babbitting is worn down to the box so it heats, how can we continue to run it without stopping to rebabbitt? Can the boxes be bushed with anything outside of rebabbitting?

7.—Admitting that the return flue and the firebox boilers are both good, what are the advantages of each? Is one any better for steep hills than the other?

A.—You can put a disc or washer on top of the valve. It does not need to be fastened, only see that it is fixed so that it cannot get out of place.

2.—If the valve is allowed to lift one-quarter of its diameter, the area of the opening will be equal to the capacity of the valve.

3.—The diameter of a valve is measured at the smallest part of the seat.

4 and 5.—There are quite a number of good kinds. The Peerless, Selden's, America, Crandall, Metallo, Pilley's, Goodsell's, Regal, Daniel's, "P. P. P.," Lubrobestos, Gordon, Duval, Gould's, and others. You will surely find some of these with your dealer. Give size of stuffing box and size of rod, or figure out the size of the packing you want. This is all prepared packing and should be cut in rings and put in stuffing box so as to break joints.

6.—In a box which is simply prepared for babbitting metal nothing will do for a substitute. Your best plan will be to rebabbitt it.

7.—The two kinds of boilers mentioned are

equally good if both are properly designed. Neither will have any advantage in climbing hills.

Q.—Can you get a double engine located anywhere in the stroke so that with no load it will not start, cutting off at three-fourths stroke?

2.—When you gear an engine so that it will run faster than the drivers are you gearing the engine up or down?

3.—Can a traction engine be run fast enough on the road to hurt anything by not using a governor belt?

A.—When a double engine is set to cut-off at three-fourths of the stroke, it should start at any point, but if the load is too heavy, there are some points at which it will not start. However the load has to be very heavy to prevent it starting at three-fourths cut-off.

2.—It is common to say that the engine is geared up rather than the drivers are geared down.

3.—Nearly every traction engine should be able to run at least 500 revolutions per minute without doing any harm to the cylinder and shaft part of the engine. This would run an engine between five and six miles per hour. The harm which might come to the engine is, that it would likely be shaken to pieces or run into something. So we think the speed at which the engine can be nicely kept in the road will not harm the engine.

Q.—I have been running a compound engine with an adjustable cut-off. When it is running "hooked

up" it runs smoothly; but when let out to full stroke it commences to pound. What is the cause and how can it be remedied?

A.—The pound is caused by the lack of compression or "cushion." By this we mean the penning up of a portion of the exhaust steam at the end of the stroke. The compression varies with the cut-off. When the cut-off is early or "hooked up," the point of compression is also early, thus penning more exhaust steam in the cylinder and making a higher compression with the result that the engine will run more smoothly. On the other hand, when the cut-off is late, the point of compression is also late and there is less steam penned in the cylinder to stop the piston, crosshead and connecting rod and it will be readily seen that when the live steam strikes the piston the loose bearings through the engine will make a "pound."

Q.—How can a compound engine do its work with less steam than a single engine?

A.—In the first place, you will notice that the high pressure or small cylinder on a compound engine is smaller than the cylinder on a simple engine of the same h. p. And since the high pressure only takes live steam this would be an indication of less space to be filled. Then the steam that is admitted to the high pressure cylinder is expanded nearer to atmospheric pressure that it is in the simple cylinder. Thus getting more work out of the steam in the compound engine.

Q.—Why is a compound engine more economical than a simple one?

A.—Compound engines are more economical than simple engines mainly because of the higher pressure with which they can be worked without involving excessive strains, and partly in consequence of the diminished loss by cylinder condensation. A very early cut-off in a cylinder causes serious condensation. The same number of expansions may be obtained in one cylinder as in two, by sufficiently early cut-off; but the strain of throwing a high pressure of steam on a large cylinder and cutting off very early necessitates enormous strength in the working parts and hence, when the expansion can take place in two cylinders, the strain is better distributed, while more smooth and even working is secured. The cooling surface is less, and the range of temperature is less in the high pressure cylinder than in a single cylinder engine with equal expansion, hence the diminished loss by condensation.—Ex. from Practical Engineer.

Q.—We have a 15 h. p. simple engine that will pull every pound as much as an 18 h. p. compound of another make, both new engines. The compound carries 150 lbs. of steam and our engine 135 lbs. Explain to me the benefit in the compound. It doesn't prove out in this case.

A.—While a simple engine may be stronger than a compound engine of greater rated h. p., yet the compound engine will do its rated h. p. of work on less fuel and water than will the simple engine. The

compound engine cannot be worked beyond its rated capacity, as can a simple engine, but the compound engine can be worked to its limit and yet be quite economical. While if a simple engine is worked to its limit it becomes very wasteful. A simple engine has to be hooked up to use the steam expansively, while a compound engine with its low pressure cylinder uses the steam expansively even without hooking up.

Q.—I have a 30 h. p. Woolff compound engine that exhausts through heater. What would be the result if I take the heater off and exhaust through pipe instead? Will the exhaust be sharper? It is now flat.

A.—A sharp exhaust is a sure sign of poor economy. It takes back pressure to produce a sharp exhaust. If your steaming capacity is good leave the exhaust as it is. If not, the exhaust nozzle can be slightly reduced. The heater will not likely have any effect on the exhaust as the opening through it is about the same as the exhaust pipe.

Q.—Which is the most economical on a large boiler and engine (high pressure) while doing work that 80 lbs. would easily do, to carry about 100 lbs. or keep her up to the point of blow-off at 160 lbs? What I'm getting at is in regard to fuel and water.

A.—The high pressure with the larger engine is always the best. The valve gear of the engine can then be hooked up thereby working the steam to a higher degree of expansion and then using less steam,

and it follows that less fuel and water will be required.

Q.—What size of exhaust nozzle would I use for straw burner 10 x 10 cylinder, about 220 revolutions and what size of nozzle for coal the same size of cylinder and same number of revolutions?

A.—The size of the opening in an exhaust nozzle is very important. It does not need to be far from the right size to do poor work. You can find the correct size by writing to the makers of the engine.

Q.—What is the reason the crosshead of an engine run one fall the bottom shoe wore over an eighth of an inch and the top shoe about an eighth of an inch? They were slide shoes to take up the wear. I could not keep the shoes from cutting. I adjusted them in all different ways. Maybe the guides were too rough for the shoes to wear smooth. I oiled them with two or three different kinds of oil, but would not stop it, how much I oiled them.

A.—Your description would indicate that there is not enough bearing surface on the crosshead shoes. The shoes should not wear three-sixteenths of an inch in ten years. However, you can help them along by the use of graphite mixed in the oil. You may be adjusting the shoes too tight. The best way to test the crosshead for looseness is to pry the crosshead up and down with a stout stick; this will show you how much play there is between the shoes and guides. There should be looseness to the amount of the thickness of writing paper. This will allow the oil to work

between the shoes and guides, and will be tight enough to keep it from knocking.

Q.—My engine has a very noticeable pound on the back center, when running under a full load. Tightening the crank and crosshead brasses does no good. The link reverse is used in which there is a slight lost motion, which causes the gear to pound slightly; I have thought perhaps this is the cause, but if so why does it not pound on both centers of the crank? Otherwise the engine runs very nicely. Can you tell me how to find the cause of the trouble?

A.—There are a great many things which may cause your engine to pound at one end of the stroke. The piston may be too close to the cylinder head, the crosshead may be out of line, the crank shaft may be out of line or the crank pin may be out of round, or not true with the crank shaft. The piston or crosshead may be loose on the piston rod or the fly-wheel may be loose on the shaft.

Q.—I have an engine of the girder pattern. The slides or guides are worn pretty bad. If I draw up the shoes on the crosshead tight enough so they won't rattle they spring the guides a little on each end of the stroke. The guides are worn the most in the center. I want to know how to plane the guides without taking the engine to the machine shop, and what tools to use.

A.—Your best plan will be to get a machinist to refit the guides. The tool which will be required

to do this work is a scraper. It will not be necessary to take the engine to a machine shop.

Q.—How far will the piston of an 8½ x 10 engine travel on the first six inches of the crank? Connecting rod six times length of crank, and will the piston travel the same distance from both ends of the cylinder?

A.—On an engine with 10-inch stroke and with connecting rod 30 inches long, the first six inches of the travel of the crank pin (measured on the path of the crank pin), will move the piston at cylinder head end three and five-eighths inches, and at crank end of cylinder two and seven-eighths inches. This difference is due to the angularity of the connecting rod.

Q.—I would like to know how to find out if my engine cylinder needs re-boring, or if the rings are worn out. Please tell of a simple way to tell if the cylinder is round.

A.—Take off the cylinder head, place the piston at say one-fourth or one-third from the stuffing box end of the cylinder. Block the flywheel so that the engine cannot move, place the reverse lever so that the valve will admit steam in the closed end. Now turn on the steam and see if the piston leaks. If the valve leaks, steam will come out of the port. However, you can tell where the steam comes from by careful examination.

If you want to find whether or not the cylinder is round, you can take a stick a little shorter than the

diameter of the cylinder and stick a pin in the end or one in both ends if you wish and adjust the pin to the size of the cylinder. Thus you will have a caliper that will show the difference in size at all points in the cylinder.

Q.—I have a 22 h. p. engine, return flue. The cylinder is 9 x 12 and my separator is a 40 x 60 Minneapolis with blower and feeder. Now I use seven tanks of 12 bbls. each of water a day of 12 hours. It fires quite easy, but it labors or appears to labor hard. The valve is set all right, but there is lots of water passes with the steam when the cylinder cocks are opened. It seems to take lots of water with the steam. Some tell me that I have too big a lead, and some that something is wrong with the engine. Please explain.

A.—The lead will not cause the water to come from the cylinder. Cold, windy weather is more likely to cause this. If you let your boiler get dirty, and have a tendency to foam, this will cause water to go through the cylinders. Use plenty of cylinder oil and hook your valve gear up as close as possible and there will be less tendency to foam.

Q.—What causes the breaking of the wrist-pin on threshing machine engines? My instance is a 13 h. p. engine running a 36-inch cylinder and a 56 rear with blower. Last year was the engine's fourth year. When we had threshed about 15,000 bushels it broke the wrist-pin and knocked out the cylinder heads. Had it fixed and threshed about 10,000 bushels when

it did the same thing again. Some say bad water caused it, others say the wrist-pin was not in line with the cylinder.

A.—Very likely your engine is a little light for the work you are doing. A 36 x 56-inch separator with blower is all a 16 or 18 h. p. engine can take care of when in the hands of some threshermen. However, a 13 h. p. engine will run a 36-inch machine, but it should not be fed very fast. Some engines are built strong enough to be run beyond their rated capacity. The suggestion that bad water caused the break will hardly stand. There may have been water in the cylinder at the time of the breaking of the pin, caused by foaming of the boiler and due to bad water, but a crank-pin should be of sufficient strength to stand a certain amount of water shocking.

The suggestion that the pin may be out of line with the cylinder is hardly the reason. The writer's opinion is that the work is too severe for the pin, and the steel becomes fatigued, or as some people say crystallized, and in this weakened condition is broken.

Q.—How will I replace the piston rings on my engine? Will they spread out with heating?

A.—Take the piston out of the cylinder, and stand the rod on the ground, head up; apply the inside of the ring to the side of the piston rod next to you, and gradually press it open with your hand until it will go down over the head; then push it down to its place.

Q.—Our engine steams up easy, but just as quick as the throttle is opened to run, the engine drops 10 lbs. of steam at once, and keeps on going down until she has not got power to pull.

2.—What is the matter with my engine? I can have 120 lbs. of steam, steam gauge and pop valve in good condition; she runs and pulls separator, but as soon as they feed the machine she will not run and pull her load with 120 lbs. of steam. What can the cause be?

A.—There must be something wrong in the cylinder. The piston may leak badly or the valve may be out of place, which may be caused by the eccentric not being in place as well as the valve slipping on the stem. There may also be something wrong with the steaming qualities of the boiler. For instance, if the exhaust nozzle was not small enough, or if it would not blow the exhaust steam up the stack. Any one of these things suggested would cause the engine to perform as you describe.

2.—In this case the engine may be too small for the work, or the valve gear may be out of place, or there may be a stoppage of the steam caused by a defective governor or throttle. A stoppage in the heater or exhaust pipe may also cause the trouble, or perhaps the exhaust nozzle is too small. With these suggestions you may be able to run down the trouble.

Q.—What is a good remedy for heating piston rods?

A.—In the first place the piston rod should be in

line with the guides. By watching the piston rod stuffing box while the engine is running you can determine whether it is in line or not. If the stuffing box gland rocks up and down with the engine in running, it is not in line and the way to move the crosshead to get it in line will suggest itself.

Another cause of heating is hard and tight packing. Take all the old and hard packing out and put in fresh packing and enough of it. After the first day's run, if you have to draw the stuffing box up to keep it from leaking, put in more packing and keep it full. The more packing you have in the box the less you have to draw it up to keep it tight; on the other hand, the less packing you have in the box the more you have to draw it up and the more likely it is to heat. If the rod is rough from heating caused by hard, tight packing, or by one side of the gland drawn up farther than the other, a good way to help out is to fix a bunch of waste or a rag on the rod close to the stuffing box by means of a wire and keep the rag or bunch of waste well oiled. This will hold the oil and deliver it to the rod by degrees and thus keep the rod lubricated continuously.

Q.—Why does my 10 h. p. Woolff compound engine wear the piston rod flat on the top side between the two cylinders where the packing box is? It began to wear the first season. Has been run five seasons.

2.—My engine has straight exhaust; no steam in heater to heat water. If I turn steam on heater and

double my feed pipe and use piston pump, will I gain anything over injector?

A.—One of a number of things may be the cause of wearing a flat place on the top of the rod. The piston rod may be bent; the cylinder head between the two cylinders may fit too loosely and therefore drop down out of center, which would make the metallic packing box ride on top of the piston rod; the metallic packing box may be out of center; or the two cylinders may be out of line with each other. The trouble can only be located by an examination of the parts by a competent mechanic.

2.—There is a gain in using a pump and exhaust heater. The steam that is taken to run the injector goes back to the boiler, but when the heat is taken from the exhaust steam there is that much advantage over the injector as the heat gotten from the exhaust steam costs nothing extra, as does the live steam sent to the injector.

Q.—How may the disc on the crank shaft be taken off and a new one put on?

A.—The old disc can be driven off with a sledge hammer. The new one can be shrunken on. The best way to do this is to place the disc in a wood fire, being sure to heat it all over, for if one part of a disc is heated more than another, it is likely to crack; after it is nearly red hot put the disc on the shaft or the shaft into the disc; the way to do this can be determined by the tools you have with which to handle the parts. Be sure to get the key ways to match.

After it is cooled the key can be fitted; care should be taken to have it well fitted the entire length so as to not throw the disc out of true.

Q.—How do you get the angle of 90° on crank when setting eccentric?

A.—Eccentrics are not set by degrees on the crank. They are usually set by the valve when crank is on center, or in some cases, by other parts of the valve gear.

Q.—Are crank pins put in by hydraulic pressure?

A.—They are pressed in by hydraulic press, screw press, driven with hammer, by shrinking, and in case of a taper fit, a screw and nut on the back end of the pin is provided to draw it into the hole. These are the common ways of doing this work. Another way, which is now out of use, was to put a key through the crank and pin.

Q.—When a double engine does not start at all points of the stroke what is the trouble?

A.—The maximum cut-off on a double engine should be later in the stroke than that of a single engine. The object of having a later cut-off is not so much to get power as to be able to start a heavy load at any position of the cranks. The cranks being set at 90° one would naturally think that a valve gear set at a little over one-half cut-off would start the cranks at any point; and it would, if the load were not too great. When the maximum cut-off is, say, five-eighths of the stroke (the one crank on dead center and the other at one-half of its stroke—the

latter only having to move a short distance till the steam is cut off) this brings the one which was on the center in position to move; but it being so near the dead point and now alone in the work, it has a poor chance to start a heavy load. Hence the advantage of having a late cut-off, for it is clear that if one piston follows its crank with steam to the point of, say, three-fourths of the stroke, the other piston and crank is so far on its travel that it can take the load alone till the former one gets off dead center again and can help itself. Thus not only is the engine ready to start at any position, but by having a late cut-off it can start a heavy load at any position of the cranks; for when one cylinder is in cut-off the other is at its best.

Q.—I have a 25 h. p. boiler and engine. What should be the right size of feed pipe from boiler to engine? The pipe on the dome is only 2½-inch connecting to 3-inch pipe to engine. When the boiler fills up to about half way between the gauge cocks the water draws over.

A.—A 2½-inch connection should be large enough for a throttling engine of this size. The size of the steam pipe does not have anything to do with boiler "drawing over." You may get some relief by hooking up your valve gear as close to the center notch as you can; and changing the water in your boiler often will also help matters.

Q.—I have a 10 h. p. engine with 7 x 10 cylinder running a 33-inch separator. The engine seems to

be a little light, but if I could make steam fast enough could get along, as there is plenty of power at 110 lbs. of steam, but the trouble is to hold the pressure. If I put a smaller flywheel on the engine and run the engine faster would it not make a better draft and enable me to keep up steam? I am using good dry wood for fuel.

A.—You are likely over working your engine, but even if an engine is overworked, the boiler should make steam enough to stall the engine. The boiler may be old and badly limed up which would make it steam hard and the exhaust nozzle may have been the right size for coal. After you are satisfied that the valve and piston are tight, the best place to increase the steaming qualities of an engine is to reduce the opening of the exhaust nozzle. If it is made of pipe you can take it out each day and reduce it, say, one-sixteenth of an inch at a time, till you have the proper steaming capacity. To reduce the flywheel and run the engine faster would not help you out for while the engine would exhaust faster it would not be so sharp.

Q.—Does a double cylinder engine take any more water and fuel than a single cylinder?

A.—A double cylinder engine should not take any more steam than should a single cylinder engine. But we can see how some double engines could take more steam than some single engines, likewise some single engines can take more steam than some double engines. It depends usually on the conditions of the

engines, and sometimes on the design. All conditions being equal they should be the same.

Q.—What is meant by back pressure?

A.—Back pressure is the pressure on the back or exhaust side of the piston, due to resistance of the atmosphere to the exhausting steam. This is 15 lbs. per square inch, and is usually increased several pounds by incompleteness of exhaust.

Q.—I have a 12 h. p. engine, cylinder 7½ x 10; the outside diameter of this cylinder is the same as 16 h. p. cylinder of the same make of engine, but with smaller bore than the 16 h. p. If I have the 7½ x 10 bored out to 8 x 10 would it give more power without changing or enlarging the steam pipe or governor? Governor is 1½-inch. Would it give the same power as the 7½ x 10 without using any more steam?

A.—It would not be necessary to enlarge your steam pipe if you bore your cylinder out to eight inches in diameter. Some 8 x 10 engines have a 1½-inch pipe, while others have a two-inch steam pipe. You will not be able to notice the difference in the working of the engine if either size is used.

Taking your 7½ x 10 engine at 12 h. p. (normal) the power will be increased a little over 1½ h. p. if you change it to 8 x 10, providing it is run under the same conditions.

To do the same amount of work with the 8 x 10 it would likely take less steam, especially if the 7½ x 10 engine was too small for the work. The reason for this is that the valve gear on the 8 x 10 engine can

be hooked up a little closer, thus using the steam to a higher degree of expansion.

Q.—Why is a piston valve engine more apt to break its cylinder head than a common D valve engine? Does not the water have the same chance to get by the valve?

A.—The piston cannot push all the water out of the cylinder either in a piston or a D valve engine, for the reason that the valve closes the port for compression at about three-fourths of the stroke. Thus the steam is compressed about one-fourth of the stroke. If there is more water in the cylinder than the clearance will hold, when the port is closed the D valve will be lifted from the seat to let the water out of the cylinder back into the steam chest and into the exhaust port, but in the case of a piston valve, it not being able to leave its seat something has to yield when there is more water than the clearance will hold. Usually there is a relief valve on the ports which has a spring and acts like a regular safety valve. The spring is set so that it will not open when the regular pressure is on it, but as soon as the pressure becomes greater due to the penning up of the water the spring will yield and open the valve, thus saving the cylinder head and other parts which may be broken due to the water shock. These valves are sometimes too small to let the water pass free enough and the engine is sometimes broken from this cause.

Q.—My engine is considerably out of balance. I realize that the counterbalance is not heavy enough

to balance the engine, and it knocks so much that it shakes the stack off the stack base. I tried to balance the engine by putting a weight in the flywheel, but this only changed the rock from an end to a side rock. Can you suggest any plan by which I can balance the engine. I could do it by having a larger crank disc made, but don't want to go to that expense. Can you give me a rule to find the amount of counterweight it requires?

A.—Rule for horizontal engine counterbalance: Add together the weight of the crank-pin, connecting rod complete, crosshead complete, and the piston complete. Multiply this by three and the length of the crank and divide by four and the radius of the center of gravity of the counterweight. This will give you the counterbalance weight.

Since you simply want to add to the weight already on the engine, instead of making a new crank disc you could make a band of one-half inch thick and the width of the crank disc and allow it to be loose enough to put lead between the band and the crank disc. The band can be made adjustable by making ears on the ends and a bolt through the ears to draw it tight to the disc and thereby hold the lead in place. The lead can be made in pieces the width of the crank disc and different amounts can be tried till the right amount is arrived at. The cavity for the lead should be crescent shape, allowing the band to rest on the disc at the crank-pin, and the bulk of the lead at the opposite side. After the correct amount is arrived at, the circumference of the band can be de-

cided on and it can be welded up solid, thus doing away with the bolt. The band can then be put on the disc, having the pin upward and the ring resting on the disc, thus leaving the crescent-shaped cavity below. The lead can then be melted and poured in the bottom and then calked in tightly. The band should not be a true circle, but fit close to the disc over half around it on the pin side, and then leaving the lead in a bulk at the opposite side of the pin. There should be provisions made to prevent the whole thing from slipping around the disc. This can be done by putting a pin or screw through the band into the disc.

CHAPTER II.

BOILER.

Q.—I have a 10 h. p. engine but very little worn. Flues 2½ inches by about 52 or 53. Shell 27 inches I think on inside. I would like to know how much increase of power or capacity I would get by lengthening boiler two or three feet, and moving the flue sheet out that distance. I see you calculate horse power by area of heating surface, but I would think the additional surface being so far away from the fire would not increase capacity in proportion. I think cylinder is 7¼ x 11. Would it be practicable to extend supply steam pipe down into and across fire chamber to act as superheater, or is there a device of that kind made for traction engines?

A.—The grate surface in a boiler should be in proportion to the heating surface. If the waste gases in the stack are not much above the temperature of the boiler, when the boiler is used at its average rate of power, the tubes are long enough and to make them longer would be a detriment, but if the waste gases are much hotter than the temperature of the boiler, the lengthening of the tubes would be a help. Some boilers are so small that the waste gases make the stack red hot. This can best be noticed at night. You do not give the number of tubes in boiler and

size of fire box, therefore we cannot tell the increase of heating surface, if tubes are made longer. We would not advise you to run steam pipe through fire box to superheat the steam as it would not pay you for the trouble in making this change.

Q.—Can a boiler blown off at night and refilled, injure the flues after working hard all day? What is the best method of keeping a boiler clean during threshing season?

A.—As a general rule a boiler should be cleaned out once a week, but in some sections once a day would not be too often. The boiler can be blown out at a low pressure, say 20 to 40 lbs. The hand hole plates should be taken off and a scraper used wherever it is possible. It should also be washed out with water. If mud or sediment is allowed to collect in the boiler the sheets are apt to be burned out, as the water cannot get to the sheets.

Q.—Is too small a water space between the top row of flues in a boiler apt to make it foam when it is working hard and under a full pressure of steam? We had quite a little trouble with foaming this fall.

A.—Boilers with large water space above the tubes are not so apt to foam. The fact that low water will help a boiler, when it is inclined to foam due to the use of bad water, will prove this point.

Q.—At 100 lbs. steam pressure on the dome of the boiler, what is the pressure at the bottom of the boiler?

A.—There will be more pressure at the bottom of the boiler than in the dome, due to the weight of the

water. For every foot in height the pressure will increase at bottom 0.4335 lb. to the square inch. In other words, if the water is 3½ feet deep in the boiler there will be about 1½ lbs. more pressure at bottom of boiler than in the steam portion.

Q.—I have a boiler 19 inches in diameter and three feet high. It is made of one-fourth-inch steel with single riveted seams and contains 19 two-inch flues 24 inches long, and is new. What pressure of steam do you think it would be safe to carry on this boiler, and do you think it is large enough to run a 3 x 4-inch engine 400 revolutions per minute?

A.—The boiler, if made reasonably well and if of good material, will safely stand a pressure of 150 lbs., and the horse power of the boiler at traction engine rating will be two h. p. The engine should run about 500 revolutions to be equal in power to the boiler.

Q.—How can you tell when a boiler is foaming?

2.—What makes a boiler foam?

3.—How can you tell where the water level is when the boiler is foaming?

4.—What is the best thing to do when the boiler is foaming?

5.—What is priming?

A.—The cylinder of your engine will very quickly tell you when your boiler is foaming. The water will get into it and cause a slapping noise. The water will be forced through the stuffing boxes and out of the exhaust pipe.

2.—The cause of foaming in boilers is due to some foreign matter in the water. The grease used in building the boiler is the cause of the first foaming. Stagnant water containing decayed vegetation is very bad water for a boiler. Water with mud or other sediment caused by mineral substance in the water will cause foaming. Alkaline water is very bad and causes foaming very quickly.

3.—When the boiler is foaming the water or foam goes to the top of the water glass gauge and it is impossible to see how much water there is until the foaming is stopped. This is best done by stopping the engine which will have a quieting effect on the water.

4.—The best thing to do when the boiler is foaming is to change the water as soon as possible. To help matters for a short while (say the latter part of the day, just before cleaning out), the steam pressure should be kept high, but not allowed to blow off at the safety valve; the water should be kept low and the load on the engine as light as possible.

5.—Priming in boilers is the water drawn into the steam pipe. It is caused by overtaxing the boiler or having the water too high.

Q.—One of experience knows well that after turning water out of boiler that a small quantity of water always remains in the boiler. Can such water damage boiler by freezing?

2.—Is mud in boiler injurious to the plates?

3.—Is there danger of the water gauge glass

blowing out when the engine is under steam and standing idle?

4.—Is it injurious to glass to shut the water out when going to dinner or for any other purpose?

5.—Will glass become hot and break?

6.—Is lead a good alloy for filling of any plug?

A.—If water is left in a water bottom boiler there must be enough to fill the space between the two sheets to do any damage to the boiler as it cannot force the sheets otherwise.

2.—It is not especially injurious, if it does not get up to the fire line.

3.—The glass is as likely to break while boiler is under pressure with the engine idle as with it running.

4.—It is not injurious to the water glass to shut the water out at times, but it will surely injure its value as a gauge and that is what it is there for. Better not shut it off unless absolutely necessary, and turn it on again as soon as the necessity for closing it is past. It is not necessary to shut it off when going to dinner.

5.—The expansion and contraction, owing to heat, is no doubt the cause of glass gauges breaking at times.

6.—Tin is better than lead as it melts at a lower temperature.

Q.—Why is it that a return flue boiler takes less coal for the same amount of work than a straight flue boiler?

2.—Why is it that a straight flue boiler or engine has more power than a return flue engine while pulling up a steep grade?

I have seen 12 to 16 h. p. engines pull their load up hills where the large 20, 22 and 25 h. p. return flue engines could not pull. When it comes to the hard pulls their piston stops. They seem to be powerless, like a gasoline engine when overloaded.

A.—It is a fact that some return flue boilers are more economical on fuel than some straight flue boilers and some straight flue boilers are more economical than some return flue boilers. It all depends on the construction and condition of the boiler. In making comparison between two boilers the heating surface should be considered rather than the nominal horse power of the boiler. There is another condition that may be misleading in such a case: if the engine on one boiler is more wasteful than the other, that boiler will take more coal to do the work. However, the boiler with the wasteful engine will take more water and the trouble can be located by observing the amount of water used.

2.—The boiler with the strongest engine and the best arranged gearing will pull the load up a steep hill the easiest. The writer is inclined to think the straight flue boiler engines are underrated, or the return flue boiler engines are overrated. It may be that neither kind are properly rated to the common standard of nominal horse power. The pulling qualities depend on the size of cylinder, boiler pressure,

revolutions of engine and speed of engine on road. The latter is governed by ratio of the revolutions of the crank shaft to the circumference of the traction wheels. A small engine with gearing arranged so that with a certain number of revolutions of the crank shaft, it will travel slower on the road than a larger engine with the same number of revolutions of the crank shaft, and gearing arranged so that the speed on the road is faster, the smaller engine may pull more than the larger engine; but it will take a longer time to do the work due to the slow travel.

Q.—The sheet around the safety plug in my engine is getting very thin. About one-half-inch from safety plug it is full thickness. Safety plug is three-fourths-inch in diameter. Crown sheet is good. How can this be fixed best?

A.—Get a new safety plug made for 1½-inch tap (which will be about 1¾-inch on outside of threads), and cut the hole larger, which will take out the thin part of the sheet.

Q.—What is the best thing to use to clean the lime and scale from the inside of a boiler?

2.—Is there any successful gasoline traction engine made?

A.—The only intelligent way to treat scale in boilers is to have a sample of the water analyzed. There are concerns that will do this free of charge and will recommend a compound suitable to your water.

2.—Gasoline traction engines are a success in competent hands. Their management, however, must be learned, same as a steam engine.

Q.—Is burning corn cobs injurious to boilers? If so, how does it affect them?

2.—Is the feeding of a little oil with water of any advantage to a boiler?

A.—Corn cobs are not any more injurious to a boiler than wood or coal.

2.—Oil is said to be a help in softening the scale in a boiler. It does not do this in all cases, depending on the nature of the scale. A trial for a short time will show whether or not it is doing the work.

Q.—Which is best; to have the old flues retipped when refluing, or to have all new flues put in?

A.—This depends on the condition of the flues. They may be taken out and retipped several times, but when they become too thin it is not good practice to retip them.

Q.—Would you inform me if a "dog house" put on a return flue straw burner engine would help to any great extent in keeping the fire back and the flues clear of clinkers?

A.—The "dog box" may be some advantage in that the fire is a little farther from the tubes, and the straw will be more thoroughly burned which may be some advantage in keeping the clinkers off the tube sheet.

Q.—Of what benefit is the water bottom in a fire

box? I have always found it very hard to keep clean.

A.—With a water bottom firebox it is easy to get a tight ash pan, so that the fire can be kept under perfect control. The lower part forms a greater receptacle for mud and sediment and it does not need to be cleaned as often as an open bottom. With cleaning out holes properly placed it should not be any harder to clean than an open bottom. The open bottom has, however, other advantages, namely, the convenience of getting at the tubes in fire box and the renewing of the fire box should it ever become necessary.

Q.—What is the method used in making tensile strength test in boiler plate?

A.—A strip is cut from the sheet and put in proper shape, which is about 18 inches long with a place in center of piece, nine inches long and one and one-half inches wide; from this size it gradually increases to two inches wide on each end. The larger part is for the purpose of being gripped in the testing machine. The piece is then pulled asunder. A record of the elongation as well as the tensile strength is noted.

Q.—I would like to find out how to jacket a boiler at home, so I ask you the question: Which is the best, the steel or wood jacket? Also how to put on and all the material to use.

A.—The steel is only to protect and give finish to the jacket. Blocks of magnesia are used to make up

a jacket on a locomotive. On some traction engine boilers asbestos plaster is used. In some cases asbestos sheets are wrapped around the boiler and others are covered with wood. Hair felt is the best. In most every case Russia iron or sheet steel is used to keep the material in place. However, in some cases the wood is put on without any outside covering and it is likely the latter would be the most convenient for a "home job." The most convenient way to put on a wood jacket is to take strips of tough wood about ⅜ x 2 inches and put them around the boiler, say about every three feet with the ends fastened together so that they hug close to the boiler. The jacket which is made of strips ⅞ x 2 inches is then nailed to these strips, which serve two purposes: one, to make an air space between the jacket and the boiler and the other to hold the jacket on while being built up until the outside metal bands can be put on which permanently hold the jacket in place. The dome is treated in the same way by first bending thin bands around for the purpose of nailing the outside strips thereto. If the boiler is of the locomotive type, a strip of wood the thickness of the jacket can be bolted to the fire box as low as the jacket can be run and the outside metal bands can be nailed to the strip. This serves the same as if the bands went entirely around the boiler.

Q.—How much coal does a jacket on a boiler save?

A.—A jacket on a boiler may in average condi-

tions save five or ten per cent. of the fuel. In a high cold wind it will save more than on a still hot day. The amount of saving will depend on the conditions.

Q.—Will putting potatoes in a boiler injure it if it removes the scale too fast?

A.—Potatoes will not injure the boiler, but too much of this diet might make it foam.

Q.—How is hydrostatic pressure put on boilers?

A.—A force pump is used.

Q.—If soot is left on flues and tube sheets, will it protect them from rust, or will it injure them?

A.—When the soot is dry it may not injure the boiler, but it will soon draw moisture from the atmosphere and set up a corrosion. It should be cleaned away from flues and smoke box, so none will be left in corners next to flue sheets, or elsewhere to get damp and rust the boiler.

Q.—What is the correct way to stop a leaky stay bolt?

A.—A stay bolt can usually be made tight by calking, but if it leaks badly and shows signs of being loose in the thread, a good way is to have some one hold a bar of iron or something heavy against one end of the stay bolt while the other end is riveted down with an ordinary size hand hammer. This will swell the bolt in the hole and make the threads fit tightly and will be more apt to keep tight than by simply calking.

Q.—What is the best way to repair a split tube—split by expanding—without putting in a new tube?

A.—The proper way to repair the tube is to take it out. One skilled in the art can weld a piece on one end which will make up for the part which is cracked and the part on the other end which is made rough by cutting it out. Perhaps the better plan would be to get a new tube.

Q.—Would a crown sheet patch riveted on the inside of the sheet be safe? It is cracked between four flues. Would it hold with bolts and a nut on the end or can it not be drawn tight enough with a bolt?

A.—The way to patch the crown sheet of a firebox is to cut the damaged part out and fit a patch on the hole, allowing two inches for a joint. All around the hole drill 11/16-inch holes, one inch from the edge of the patch and two inches apart. Mark the holes on crown sheet, through the holes in the patch, drill the holes in crown sheet for five-eighths-inch tap. Tap the holes in crown sheet and countersink them in the patch to fit patch bolts. The patch bolts have a head like a wood screw, but instead of a slot in the head they have a small square end for screwing them in, which is cut off after screw is in place. Screw all the bolts up tight before chipping off square end and then calk the joint to make it water tight.

Q.—I own a 15 h. p. compound engine. Last fall I had new flues put in by a good man and they had to be rolled twice. I got them from the ———— Company. It is a locomotive boiler and the flues were never beaded at the smoke box. Would that have anything to do with them leaking on the other end?

A.—Having the tubes not beaded at the smoke box end will not cause them to leak at the firebox end. The thing which causes tubes to leak more than anything is allowing cold air to rush into the firebox while the tubes are quite hot.

Q.—How much does a rivet seam weaken a boiler sheet?

A.—A single riveted seam, properly proportioned, has 65 % of strength of the sheet. A double riveted seam has 70 %, and a triple riveted seam has 75 % of the strength of the sheet.

Q.—Will two-inch tubes last longer in a direct flue straw burner than three-inch?

2.—Does an engine with large heating surface steam easier than one with less heating surface, or does it depend on other things also?

A.—There should be no difference as to the length of time a two or three-inch tube will last in a boiler. The two-inch has come into use more because a greater amount of heating surface can be obtained by its use, due to the fact that a much greater number of them can be gotten into the boiler with less dead space.

2.—The engine with the greater amount of heating surface will steam the easier. Of course, there is limit to the amount of heating surface a boiler will stand in relation to the grate surface, but there is no traction engine built which has too much heating surface.

Q.—What is the usual cause of a boiler explosion?

A.—The one great cause of boiler explosions is the inability of the boiler to withstand the pressure to which it is subjected at the time, and this may be brought about by any one of the following causes, viz.:

1.—Bad design, in which the boiler may not be properly strengthened by stay bolts and braces; deficient water space, preventing the proper circulation of the water.

2.—Bad workmanship, caused by the punching and riveting being done by ignorant and unskilled men.

3.—Bad material caused by blisters, laminations, and the adhesion of sand or cinders in the rolling of the plate.

4.—By excessive pressure caused by the gross carelessness or recklessness of the engineer or by defective steam gauges or inoperative safety valves, they being screwed down too far, over weighted, jammed, or otherwise out of order.

5.—By being used too long so that the sheets become thin and weakened and thus give way to the pressure.

Q.—Why is the boiler problem getting to be such a serious one? I know of some real old boilers which have their first set of flues. In modern boilers the flues last from one to five seasons. Is it the material and workmanship or in the different way they are handled?

A.—When the "real old" was built, it was large

enough to run its engine to do the work which was required of it at that time, which was, say, a separator. It could do this work quite easily at from 60 lbs. to 80 lbs. boiler pressure. If these old engines are run at the same rate now or at a slight advance in pressure they are still durable engines. By and by, and one after another, the automatic stacker, the pneumatic stacker, the band cutter, the bagger and weigher were hitched to the separator and practically the same size engine and boiler is doing this additional work to-day. When the engine is found to be too small the safety valve is reset. The boiler is made heavier, the engine is thickened at its weak places, but the same general dimensions are maintained. The tubes have the same spacing that they had, the water space around the firebox about the same, only a little less, due to the extra thickness of the boiler plate. The engine having to do much more work, thus the boiler has to evaporate more water, and the more water evaporated the more sediment in the boiler. The pressure raised from, say, 80 lbs. to 150 lbs., will make about 140° higher temperature in the boiler, thus a hotter fire. In some cases of spacing of tubes and water space around firebox, the space is so scant that the extreme heat drives the water away from the sheets and from between the tubes and thus causes trouble.

Q.—The boiler and engine I have been running have been in use 14 years. The machine was built by a thresher company whose reputation for good ma-

chinery and workmanship has been well established. In firing up after the boiler has been cooled off, I notice a cracking noise, very much like the noise made by a barrel of water in freezing weather. Do you consider this an indication of any weakness on the part of the boiler?

A.—The strange noise you hear when firing up your boiler is likely due to the expansion of the metal. There are likely some brackets fastened to the boiler and an unequal expansion would cause them to creak. There is likely no harm being done.

Q.—The side plates in firebox of a boiler are slightly bagged (one-fourth-inch) between staybolts where the same are set more than the regular distance apart, owing to slanting seams in the plates. The stay bolts leaked slightly, but were easily tightened with a hammer. Boiler was steamed up later to normal pressure, 150 lbs., and appeared to be all right. As the places are covered on the outside by the axle brackets, making it unhandy to put in extra stay bolts would you consider it safe to run the boiler at normal pressure (150 lbs.) without putting in extra stay bolts?

A.—The firebox of boiler was likely strained while running with a pressure which was higher than the working pressure of the boiler. The boiler should stand 150 lbs. pressure, if it was built for that pressure, even if the sheet is slightly sprung by misuse in the past.

Q.—Near the close of our threshing last fall we

were troubled with the steam gauge on our engine. Valve was set to pop at 150 lbs., but wishing to carry higher pressure and the company recommending the boiler for 160 lbs., we set the valve to pop at that, according to a gauge that we used several years. Immediately after the steam gauge gave way, the ratchet being worn and the hair spring tangled. After adjusting a new gauge of the same make (Ashcroft) it registered 175 lbs. before popping. When shutting down we noticed that the side plates in firebox were slightly bagged between stay bolts in places where the same are set more than regular distance apart, owing to the slanting seam.

A.—While your boiler might have stood 160 lbs. without bulging the sheet between the stay bolts, 175 lbs. is evidently too much pressure for it. A good plan is to carry the pressure which the engine is built to carry; which in this case is 150 lbs. It is very likely the pressure was 165 lbs. before you adjusted the safety valve, being misled by your defective gauge.

If you cut your pressure down to 150 lbs. your boiler will likely not give you any trouble. The bulges between the stay bolts will not do it any particular harm. However, it does not look well; but since you know the pressure which caused the bulge and knowing you have 25 lbs. less in the boiler you can be assured that it will not bulge any more and that it should be quite safe at 150 lbs. pressure.

Q.—Will you kindly advise me in regard to a

30 h. p. engine? It is a 30 h. p. return flue not far from here, but I hear it foams badly. Are they liable to foam? What is the cause? Are they not small for their rated horse power?

A.—When a boiler is too small and when it has to be fired hard it is apt to foam, especially if the water is bad. The trouble can be reduced by freely lubricating the cylinder and hooking up the valve gear as much as possible, thus taxing the boiler for steam as lightly as possible and bringing the tendency to foam to a minimum.

Q.—To what pressure should a cold water test be made? Is this a reliable way to test a boiler?

A.—Most authorities require double the working pressure for a water test. The hydraulic test when applied to boilers should always be accompanied by careful sets of gaugings, lines being strung across the parts to be gauged and measurements taken, before, during and after the test, to ascertain the amount of bulging, and also the permanent set, if any. A blind pumping up of the pressure without any regard to the behavior of the structure is calculated to do more harm than good. The test should only be applied under the supervision of a specially skilled man.

Disastrous explosions have occurred from the practice of inexperienced persons along this line. Instances have occurred where boilers have burst shortly after they have been tested by hydraulic pressure much beyond the working pressure. It is like an engine pulling a heavy load up a steep grade and then

breaking while going down on the other side of the hill when the engine is practically pulling nothing.

Q.—I have an engine which leaks water at the corners (back) of the firebox. Can you give me a recipe for a cement which applied on the outside would stop it, or tell where I can buy it? It is impossible to calk without taking all the gears and drivers off. Can get a cement that is advertised in Power, but don't think it is just what is needed, hence this letter to you.

A.—We know of nothing which can be applied to the outside of a boiler to stop a leak except the calking tool. When you clean out the boiler put a few potatoes inside near the leak. They will cook up and get into the leak and may stop it. Horse manure is said to be very good for the purpose. In time the leaks may corrode and lime up and will save you the trouble of taking your engine apart.

Q.—What causes stay bolts to leak in the side of a firebox boiler when it is left clean?

2.—Is artesian well water injurious to boilers? That is, will they rust out and become weakened when not in use? Is there any rust preventive on the market? The artesian water around here appears to be soft as rain water, but when it has been in a pail or pipe they become badly rust eaten.

A.—Usually undue expansion and contraction of the sheets of the boiler. It sometimes happens that the water is not put into the boiler at the proper place. The best place to put the feed water into a boiler is

near the front of the boiler. If the water is put in at the firebox end, the stay bolts are sure to leak.

2.—When there is iron in the water it soon colors a tin bucket. If a boiler is thoroughly drained when put away and then closed up the action of the water can do no harm to it.

Q.—What is the cause of a safety plug in a boiler melting when there is water over the crown sheet?

A.—This sometimes happens when the plug does not extend far enough through the sheet on the water side, and projects too far from the sheet on the fire side and when the tin is partly melted out, in time the small part which is in the sheet is blown out. A fusible plug should extend at least three-eighths inch into the water, and the cavity for the tin made cone shaped, so that the pressure tends to keep it tight and there will be no danger of melting or blowing the plug out when water is over the crown sheet.

Q.—What is the cause of a main flue leaking around where it is riveted to the flue sheet and how can I fix it?

2.—Where can I get new flues, 3½ inches by 10 feet long at a reasonable price?

A.—The heat, combined with the expansion and contraction usually starts a leak. Calk the leaks. A real dull cold chisel will make you a fair calking tool for the purpose.

2.—You can get tubes for a boiler at any branch house of the engine's company at which made. They have them cut any length to suit their engines.

Q.—Why are the flues so much more apt to leak in the firebox end than at the smoke box? I notice that my flues are almost tight when I am pulling a load, but after I shut the engine down the water runs out of them at a great rate. What makes it do this? Someone has been telling me that the flue sheets are not thick enough to hold the tubes, but I find that it is one-half-inch thick in the firebox and three-eighths inch thick at the smoke box end. Would a thicker flue sheet in the firebox keep the flues tight? Which is the best way to make them tight, by rolling or calking?

A.—The flues or tubes are more apt to leak in the firebox on account of the great heat. The water not being able to carry off the heat fast enough therefore the surface next to the firebox becomes overheated and too much expansion takes place, and the continual expansion and contraction works them loose. The reason the tubes are tight while running the engine and then leak after the engine is shut down is that while the engine is running the fire is made hotter and the tubes become tight in the holes by expansion, and after the engine is shut down the exhaust steam has ceased exciting the draft, therefore, the tubes will cool off and contract, and in consequence become loosened. This tightening process from the heat will not last long. In a short time the tubes will become so loose that they cannot tighten when the extra heat comes on. There is another reason why the leak is not noticed while engine is

pulling, and that is the hot fire dries up part of the leak and carries it through the tubes with the heated gases. A thicker tube sheet in the firebox would make the matter worse instead of better. The thicker the sheet is the farther the water is from the fire and the less capable the water is to carry off the heat, and the more overheated the surface next to the firebox will become. Instead of making it thicker, the writer thinks that if it were thinner it would do better.

When the tubes become loosened they should be rolled or expanded. Calking or beading will do little good when they are loose.

Q.—Do you consider it dangerous to run a traction engine without a safety plug?

2.—What kind of metal is a safety plug filled with?

A.—The crown sheet of a boiler is in danger without a safety plug. If the water is allowed to get below the crown sheet, the stay bolts and seams will start to leak, and oftentimes the sheet will bag between the stay bolts.

2.—Block tin is used to fill safety plugs. Solder, babbitt metal or lead will do in an emergency.

The plug is screwed out, the metal poured into the plug and then hammered to make it perfectly tight.

Q.—I bought a second-hand Minneapolis engine a few years ago and the main flue over the fire is warped down a little. What would be the proper way to fix it? Heat and spring it back or put stay bolts in it to hold it? Some machine men advise me

to leave it the way it is. Please give me your advice.

A.—You cannot put stay bolts in the fire flue as it is surrounded with tubes. If it is not warped too much you might take the machine men's advice. If you want to get it up again, the best way is to heat it; which can be done with a large gasoline torch or by placing a grate with a charcoal fire up to the place; then with the aid of a screw jack and hammer you can get it in place again. Scale is likely the cause of the dent, and it should be cleaned off, which can be done by hammering on the inside of the flue.

Q.—Does it weaken a crown sheet by pounding out bulges by heating it or should it be done cold?

A.—It is better to heat the plate to drive out the bulges. The writer is of the opinion that the bulges can do no harm and that it is not worth the trouble to straighten the plate.

The thing to be careful of is to see that sediment does not collect in the bulged places, thus causing the sheets to become overheated and in time become cracked. This can be avoided by frequent examination and cleaning.

Q.—Is a boiler dangerous to use when the crown sheet has a bulge in it of about one-fourth of an inch? If so, how can it be remedied?

A.—A slight bulge cannot do any harm to a crown sheet. The bulge was no doubt caused by low water, which is not good for the sheet, but after the sheet is slightly bulged it is not worth your while to try to straighten it.

Q.—Will it hurt a boiler to let the water stand in it while not in use for a week or two? Also do you think it good policy to use boiler compound to clean a boiler when using hard water?

A.—While water left in the boiler for two weeks cannot injure it much, yet it is a good thing to take it out. Water cannot be changed too often.

Q.—Which is best, copper ferrules in flue sheet in firebox or flues put in without copper ferrules? I notice some boilers have them and some have not. I recently have replaced some flues in my boiler and found the ferrules burned out half way through the flue sheet. Would not a boiler be better without them?

A.—Boilers are made with and without copper ferrules, both with good success. However, it depends very largely on the workmanship in either case. There may be more chance for poor work in the use of ferrules as the usual custom is to make the hole in the tube sheet large enough to slip the ferrule in the hole and around the tube. In this case the tube has to be expanded enough to take up two loose joints. Another way is to make the holes smaller so that the ferrule can just be slipped in and then expanded in the hole and the tube then slipped in the copper lined hole and then expanded. The latest practice in placing tubes without ferrules is to make the hole in the tube sheet smaller than the tube. In this case the tube is reduced on the end by means of a die and then driven into the tube sheet to its proper

place—this applies only to the firebox end of the tube. The smoke box end is made in the regular way which is loose enough to slip the tube through. The firebox end being put in the above way is not unduly stretched as after it is expanded it is about the same size at tube sheet as the other part of the tube.

The writer is partial to this method.

Q.—Is freezing injurious to a steam boiler? If so, in what way? Is it liable to cause any unseen injury that would render the boiler unsafe? What pressure would ice exert per square inch? How much does water expand in freezing?

Is it better to open up throttle or valve after steam has gone down in freezing weather?

A.—Freezing a boiler injures it. In a firebox boiler, if the bottom and sides freeze solid, the sheets are stripped over the stay bolts. Sometimes the water is run out of a boiler and mud is left in the bottom and sides which when frozen will also strip the threads from the stay bolts. Water expands when frozen 8½ %. In this case the expansion will take place in the direction of the weakest place, so if there is three inches space between the sheets, the expansion will be something like one-fourth of an inch. This amount would only take place in the bottom of a water boiler providing the water is well up on the sides.

Water will freeze in the boiler when the temperature gets below freezing point. To prevent this a

slow fire should be kept up. In case of a moderate freeze, say, 25° F., very little fire in the boiler will take it safely through the night, especially if there is a moderate steam pressure on the boiler in the evening.

There is no advantage to be derived from leaving the throttle valve open. The valve should be tight and steam pipe should be constructed so that the condensation between the valve and the boiler can return to the boiler and between the throttle and cylinder it should be properly drained. In case of a leaky throttle the drains will freeze up in severe weather and there is danger of bursting the cylinder.

In an open bottom boiler two inches of water will do no harm, if frozen, as the ice not being sufficiently confined and being allowed to bulge up in the center will save the boiler from being forced out of shape. More than two inches may prove fatal.

Q.—If three or four flues are leaking in a boiler, is it proper to bead or expand, or both?

A.—If the flues are loose, it is necessary to expand them. While it might be possible to stop the leaks by beading yet it would not last. Usually when a flue leaks it needs expanding. The beading is more to protect the flue sheet.

Q.—I take the liberty of asking you how to repair a flue sheet where it is cracked between two flues.

A.—When a flue sheet is cracked between the flues it generally takes a new sheet. But you may

be able to calk it so it will hold. The writer does not know of any way to patch the sheet as the flues are generally too close for patching. Careful calking may answer the purpose for a long time.

Q.—The flues in my engine have been leaking a little lately. Sometimes they would leak for half an hour and then they would stop entirely for a half day. What do you suppose would cause this?

A.—Your leaky tubes should be rolled or expanded. If they get real hot they will close up partly and the excessive heat will dry up the remaining moisture as it comes through the leak. Never leave your fire door open when the engine is pulling hard as the inward rush of cold air will contract the ends of the tubes and get them loose. If possible never make an unduly hot fire. Your tubes will last longer, if you observe these points.

Q.—How much should the ends of the flues project past the flue sheets to be properly beaded? Should the ends of the flues be annealed before beading?

A.—Three-sixteenths of an inch is the right amount to allow for beading. New flues are usually soft enough for expanding and beading; but when old flues are replaced they should be annealed

Q.—I have an engine in which the flues are hard to keep from leaking. It is a return flue boiler and there is no copper packing around the flues in the front end. Would it be advisable to ream out the holes in the flue sheet so as to get room for copper?

Please give full directions for putting in flues, what kind of expanders to use (sectional or roller), how should the flues be annealed, etc.

A.—There are some manufacturers of traction engines who never put copper ferrules in their boilers, who are very successful in keeping their tubes tight. You would likely not be benefited by putting ferrules in your boiler. A great many men have trouble with their tubes on account of not using the boiler right. In some cases where straw is used, a very hot fire is kept burning for a time and cold air is left to rush through the tubes while they are in this overheated condition, thus contracting the ends and making them loose. A steady fire will save lots of trouble. Do not neglect the fire and then overheat the boiler to make up for lost time. It then becomes too hot and often is cooled down too fast and thus the trouble.

Q.—Please tell me which is the better flue expander, whether roller or spring, for flues two inches in diameter.

A.—The roller or the Prosser are equally good flue expanders. It is simply a matter of taste.

Q.—Which is the best way to remove leaky boiler stay bolts, also which is the best way to take out leaky flues so as not to damage flue sheet?

A.—To take stay bolts out of the boiler, cut the bolt out with a cape chisel the thickness of the sheet; then drop it to bottom of boiler and draw it out from the hand hole. It is very seldom necessary to take

stay bolts out on account of leaks. If they are re-riveted with a heavy hammer they can be made tight. Have some one to "hold on" the other end of the stay bolt while the riveting is going on. It should be hit pretty hard so as to swell the thread in the sheet and thereby make the bolt have a tight fit. If it is necessary to calk it a little the calking will then hold.

If the flue is at the top or bottom or at a place where it can be gotten out through a hand hole the flue is cut off just inside the flue sheet. The piece left in flue sheet is then carefully taken out, first by chipping off the bead and then with a cape chisel making a cut in the flue, which is then easily collapsed. To take a flue out in the center of the head, through the flue hole, is a little more difficult. The bead is chipped off of each end, three or four cuts are made with a cape chisel at each end so as to reduce it in size where it was expanded in the head; if a copper ferrule was used the tube will not be hard to get out, but where copper ferrules are not used and the flues are limed up a great deal of work is required to get them out; as the lime has to be worked off by drawing and pulling. It sometimes pays to take a flue out which is all right in order that a bad one may be taken out through the hand hole.

Q.—What is the best way to fasten loose boiler brackets to traction engine boilers? The brackets have worn loose on bolts and burrs cannot be drawn up tight enough to keep brackets from working loose. Can this be fixed without putting in new bolts?

A.—Sometimes the bolts fit so tight in the boiler that it is impossible to draw them down tight against the brackets. In this case the bolts might be taken out, and the threads oiled and then put back. The taking out of the bolts and replacing them will wear the threads enough to allow them to go farther into the boiler. Some brackets are bedded in zinc. In this case the old zinc should be taken out, the bolts put in their place (not drawn up tight) and zinc run in again, then draw the bolts up solid. It is not necessary to put in new bolts when the old ones are good and tight.

Q.—Will you please give full particulars for putting in new flues and taking out old ones? What is the best flue for repair work, iron or steel? Do copper thimbles add to the durability of a flue? Just how much should a flue extend beyond the flue sheet? How should a person proceed after the old flues are out? Should we put in one, let it project the right distance at each end, then turn it down at both ends? Do you turn them over at end first with a machinist's round headed hammer? Can flues be put in proper with a flue roller, a beader and hammer, or must an expander always be used? Please give full particulars for taking out old and putting in new flues, so that a man of good judgment, although he never put in any, can do so without the aid of a boiler maker.

For leaky flues should the beader be used after the flues have been rolled?

A.—The Shelby seamless, or charcoal lap weld tubes are the best.

For taking out tubes, see the foregoing. A copper ferrule is a good thing when the hole is too large for the tube. When it is used, the ferrule should be expanded in the hole before the tube is put in. In new work some manufacturers advocate the use of ferrules and some advocate making the hole at the fire-box end a trifle smaller than the tube and swedging down the end so as to drive it in place; thus after the tube is expanded it is not made any thinner than it was originally.

A tube should extend three-sixteenths of an inch beyond the tube sheet for a bead. The tube is then expanded at both ends and then hammered over to make the bead. Then expand a little again, then use the beading tool. Be careful not to expand too much. There is more danger in a beginner expanding too much than not enough.

Do not try to stop leaky flues by beading or calking. Always use an expander. If the bead does not seem to lay up to the tube sheet the beading tool can then be used. The object is to get the tube tight in the hole which can only be done by the expander.

Q.—I have a water tube boiler the body of which is made of cast iron one-half-inch thick. It is oblong, 36 inches long, 16 inches wide and 4 inches thick. It stands on one edge and has 125 one-inch pipes screwed into one side, extending out one foot; the outer ends of the tubes are closed. The body has stay bolts cast into it two inches apart. At every hole in the body the iron is increased to three-fourths-

inch thick. Is this a good kind of boiler, and what pressure can it carry?

A.—Cast iron is not a safe material for boilers. While it may be made thick enough to stand a good pressure for a time, yet the uneven expansion and contraction of the brittle metal may cause it to weaken and suddenly give way, to the pressure that is on it. However, the manufacturers of this boiler may be able to tell you from experience what a safe working pressure would be and how long it would stand the pressure.

Q.—My boiler is leaking around the fire door, both in the rivets and between the plate and the door ring, both inside and outside; and especially around top of fire door. Now which is the best way for stopping the leak? There are also a few stay bolts leaking a little.

My boiler is new; has run only one season, and is made of 5-16-inch plate, with heavy stay bolts 4½ inches apart; it is a Mogul boiler.

A.—The only thing to do is to calk the joints, rivets and stay bolts. The places where you cannot get at while it is steamed up, you can mark with chalk and go at it when it is cool enough to get into it. If you get it water tight, it will be apt to be tight under pressure. If you have a crosshead pump, you can fill the boiler full of water and by turning the engine by the flywheel, you can pump up a good pressure, which will find the leaks for you.

Q.—The soft plug in my boiler has melted out with the glass gauge half full of water. I have put

an iron plug in place of it until I can get it filled and put back again. Please tell me what kind of metal to fill it with and what made it melt out when there was plenty of water over the crown sheet. Also how much more heat it requires to melt the metal than there is in the water at 150 lbs. of steam?

A.—Tin is used for filling fusible plugs. The reason for it melting out when there was water over the crown sheet is that it likely projected too far into the firebox. That is, it did not extend far enough into the water. The plug should screw through the sheet far enough so that the water can surround the plug where the soft metal is held, say at least half an inch.

Tin melts at about 445° F., and 150 lbs. of steam has about 365° of heat, so it takes 80° of heat more than there is in the steam to melt the tin. The tin being so close to the fire that the water cannot carry off the heat sufficiently to keep the tin to the temperature of the water, so that there is a less margin than 80° to keep the tin from melting.

Q.—I have a 15 h. p. Advance coal burner which I converted into a straw burner last fall by putting in a fire brick arch, dead plate, suitable grates, etc. Also cut a four-inch hole in left side of boiler and put in a piece of flue. I then made a screen and straw chute. I was bothered considerably with straw sucking over end of arch and burning on end of flues causing a crust of ashes to form, which gradually shut off flues. By opening hole in side one could see the flame come over end of arch and it

seemed to have great force or suction. I use a 1⅝-inch exhaust nozzle and arch is 3¼ inches from crown sheet at highest point. Do you think arch is too close to crown sheet, thereby causing too great a draft over end of arch? I have always understood that the area of opening between arch and crown sheet should be nearly as large as the combined area of flues. I have 51 1¾-inch flues and opening over arch is 3¼ x 24¼. I pull a 36 x 60 Advance separator, Parsons feeder, telescope elevator and Reeves stacker with engine.

A.—Your construction seems to be all right, excepting perhaps the bushing in the exhaust nozzle, which may be too small. This should be made as large as possible, allowing just enough forced draught to burn the straw. If it is too small, you will have trouble with straw flying through the fire and burning across the tubes. At the best there is enough of this to contend with, and the milder the exhaust the less trouble with the tube sheet. Do as little stirring in the fire as possible as this too adds to the trouble of flying straws.

Q.—How can safety plug which appears to be limed in be taken out without injuring crown sheet?

A.—In taking out the safety plug you are more apt to injure the plug than the crown sheet. If the plug will stand screwing out no harm will be done, but if the plug is so tight that it will twist it off a little hammering round the plug may loosen it up. Care should be taken not to hammer too near the stay bolts as they may be loosened and made leaky.

Q.—I have a 40 h. p. boiler which was re-flued, and in about six months the flues began to get holes in them; have had to put in about a dozen new ones. I would like to know what was the probable cause. Was it poor tubes or bad water? I would say when taken out they were perfectly clean, only these spots that were pitted.

A.—Your trouble is very likely in the water. Iron flues will stand bad water better than steel ones and the best kind you could use would be lap welded charcoal iron flues.

Q.—What would you consider the standard h. p. of these different engines and boilers:

Engine No. 1, has boiler waist size, 28 in.; length of tubes, 78 in.; number of tubes, 42, diameter, 2 in.; length of firebox, 40 in.; width of firebox, 26 in.; height of firebox, 32 in; size of cylinder, 8 x 10.

Engine No. 2: Length of firebox, 36 in.; width of firebox 26 in.; height of firebox, 32 in.; length of tubes, 78 in., diameter, 2 in.; number of tubes, 42; waist size, 29 in.; cylinder, 8½ x 10.

Engine No. 3: Waist, 28 in.; firebox, length 40 in., width 25½ in., height 37 in.; number of tubes, 36; length of tubes, 84 in., diameter, 2 in.; cylinder, 9 x 12.

2.—Will an engine, say, 7 x 10 cylinder, give out as much power on a 12 h. p. boiler as the same size engine, 7 x 10, would on a 15 h. p. boiler? Both boilers having the same steam pressure, say, 110 lbs.

3.—Are boilers always rated by the heating sur-

face? If so, how many square feet of heating surface is considered a horse power?

A.—It is presumed that you have in mind nominal h. p. As you give no conditions under which these engines are to run, all we can do is to make a comparison between the sizes given in question. We will base our calculation on engine No. 1 and call it a 13 h. p. both in cylinder and boiler and if it is 13 h. p., No. 2 boiler would also be 13 h. p. as there is very little difference in the size and the cylinder of No. 2 would be 14¼ h. p. No. 3 boiler would be 12½ h. p. and the cylinder would be 16 h. p.

There is a great difference in the rating of engines made in this country as each manufacturer has a different standard to figure from. Some carry higher pressure than others; some run at different speeds and different points of cut-off to accomplish the same results. Some boilers have to be fired harder than others. As the power of a steam engine is very flexible there is usually a wide range as to the amount of work which can be done.

2.—A 7 x 10 cylinder is generally termed as a 10 h. p. There would be no difference in the power if put on a 12 or 15 h. p. boiler. The difference would be the larger boiler would steam the easier.

3.—Boilers should always be rated by heating surface. Twelve square feet of heating to a nominal h. p. is considered good practice in this country, but some manufacturers give more and some less.

CHAPTER III.

VALVE GEAR

Q.—Please explain the difference between a balanced and unbalanced valve on a steam engine?

A.—In an engine slide valve the common D type is an unbalanced valve, and the flat pressure plate and piston valves are balanced. In the piston valve the port is in the entire way around the valve, with the exception of small bridges which are used in some cases to prevent the rings from dropping into the port. In the pressure plate valve the ports are on both sides of the valve, and in the unbalanced, or D valve, the ports are on one side only, which allows the steam to hold the valve up to its seat thereby making it unbalanced.

Q.—Would you please describe the Corliss valve gear?

2.—What kind of a valve is the best? A piston valve or a common slide valve? Which is the easiest on the link and eccentric?

A.—A Corliss engine has four valves, two on top and two at bottom of the cylinder. These valves are of the oscillating type and are driven by a wrist plate, and the wrist plate is driven by an eccentric. In modern Corliss engines there are two eccentrics; one for the inlet valves, which are at the top and the other

for the exhaust valves which are at the bottom. The exhaust valves are positive driven, having the same time and length of stroke at all times, while the inlet valves are varied in length of stroke, thus varying the cut-off of the steam. This cut-off is controlled by the governor which makes it an automatic cut-off engine. The Corliss engine was the first automatic engine.

2.—It is difficult to say which is the best. A piston valve runs the easier, being perfectly balanced, but in a short length of time is subject to leaks; while the common slide valve runs the harder, is harder on the valve gear; but wears to its seat and is apt to keep tight for a much longer time.

Q.—About how much lead must a valve have?

2.—Which is the more economical and will give better results, a valve set with an equal lead and an unequal cut-off or with an unequal lead and an equal cut-off, and why?

A.—One-thirty-second of an inch is usually the right amount of lead for the average size traction engine.

2.—There will be very little difference in the economy of either way but the equal cut-off will give better results, and will give a uniform sound to the exhaust, which is desirable.

Q.—In setting the valve on a traction engine after eccentric is properly set and the valve properly set with reference to lead and lap, having the engine on dead center is it necessary to set it to cut-off at three-fourths stroke or will this be done when the eccentric

and valve are properly set? Explain fully and clearly.

A.—In a single D valve where the lap is fixed the lead fixes the angle of the eccentric and the cut-off does not need to be considered. The cut-off will take care of itself. Of course in designing valve and ports the cut-off is an important factor but not in the setting of it.

Q.—My engine is a 12 h. p. ———. Now the directions say to give the engine as much lead on one side as on the other; but if I do that she will not exhaust right. She will exhaust harder one side than on the other. Otherwise she runs smooth and nice. The eccentrics are correct. She runs the same forward or backward. Can you tell me the cause of it?

A.—The uneven exhaust is caused by an uneven cut-off. In most valve gears, including the link valve gear, the cut-off is not equal on each end when the lead is equal. To have the exhaust sound alike on each end the cut-off must be equal, and to get an equal cut-off the lead must be greater on one end than on the other making the lead on the end next to the crank shaft least.

Q.—I have an engine and I can't get the valve set to my liking. When the engine is on the center and the reverse lever is in the last notch, the valve opens one-eighth of an inch more at the end in which the engine is running than at the other; and when it is reversed it opens one-eighth of an inch in the direction which it is running. Please tell me in The

Review how I can get it right, or if there is anything wrong with the valve gear.

A.—This is a common failing in most all valve gears. In fact it indicates that a more important point than equal port opening is correct. If a valve gear would show an equal port opening with an equal lead the point of cut-off would likely be unequal. So the chances are, your engine is all right. This discrepancy in the port opening, lead and cut-off are due to the angularity of the connecting rod, and it can be shifted to a point where it can do the least harm. This discrepancy can be overcome in four-valve engines where each valve can be set independently, but in a single valve the motion cannot be made perfect.

Q.—How do you set the valve on a double cylinder simple portable engine running one way all the time; has no reverse; run backwards or same as a traction engine does on the road; upright used to run a merry-go-round. Valves are run by a single eccentric each.

A.—Each valve is set by itself as though it were two separate engines.

Turn the eccentric to its extreme, throw one way and note the port opening, then turn it to the other extreme and note the port opening on the other end of the valve. If the one end has more opening than the other, the valve should be set on the stem so that the port opening is the same on each end, when the eccentric is thrown from one extreme to the other.

When this is accomplished set the crank pin on one of the dead centers and turn the eccentric on the shaft in the direction the engine is to run until the valve opens the port about 1/32 of an inch on the end of the cylinder at which the piston is then located. Now fasten the eccentric on the shaft and turn the engine in the direction it is to run, until the crank pin is on the other center, and see if the lead is 1/32 of an inch at the other end of the valve. If it is not the valve can be moved a little on the stem, or the lead can be increased or decreased by moving the eccentric on the shaft.

Q.—Which would be the best way to get lead equal on both front and back of the Woolff reverse? Suppose it is cutting all right on the front side. What would have to be done to raise or lower the stand, or would it do to babbitt pillow block boxes? Suppose it wore and raised shaft so as to throw it out of line?

A.—The best way to get your gear in proper shape is to first set your reversing shaft, which can be tested by placing the engine on center, and then have some one pull the reverse lever backward and forward while you watch the gear. If the reversing shaft is in its proper place the valve rod will not move while the reverse lever is moved. This should be tried while crank pin is on each center. If there is no provision made for shifting the reversing shaft boxes, they can likely be rebabbitted. This however, is not necessary, if the discrepancy is slight. After upper end of eccentric yoke is central with the reversing

shaft all there is left to do is to see that each end of the valve has the same amount of lead. This is done by shifting the valve.

Q.—My engine has Woolff reverse gear. When engine is on center the valve moves 1/16 inch. If I move eccentric on shaft it will not move on one center, but turn it over to the other center and it makes valve move one-eighth inch. Dead center being found with a transit sent by the company. That is, the valve moves when the reverse lever is moved back and forth. Can you tell me what the trouble is? Is it possible to set a valve when valve moves one-sixteenth inch as above described?

A.—Part of your trouble is in the setting of the reversing shaft. It is either too high or too low. It is more likely too high, as the crank shaft wears down and the reversing shaft does not. You can either fix this by raising the crank shaft box or lowering the reversing shaft box. To find out which way to move this you can put the engine on its center and have some one pull the reverse lever backward and forward while you watch the movement and the right way and part will suggest itself. Between the moving of the crank shaft or tumbler shaft and the eccentric you can get the valve to stand still, while the reverse lever is moved backward and forward. From your description of the case we think half of the error is in the location of the reversing shaft to the crank shaft and the other half is in the location of the eccentric.

Q.—Does the lead vary or is it constant when notched up or hooked out on the Woolff valve gear?

A.—When a Woolff valve gear is correctly set the lead should be the same at all points of the cut-off. If it is not, the eccentric is out of place or the reversing shaft is not in its right place. When the engine is on dead center the upper end of the eccentric yoke should be central with the reversing shaft. When it is in this position the valve will not move while valve gear is reversed and the engine is on dead center. If the valve does move the eccentric yoke should be watched while reverse lever is moved and notice taken where it should be moved to bring the end of the yoke central with reversing shaft, which will accomplish a constant lead at all points of the cut-off.

VALVE GEAR—LINK MOTION.

Q.—On an engine with link motion reverse, where two eccentrics are cast together can you change the lead of the valve in either or both forward and backward motion without resetting the eccentrics or having new ones made separate so you could move them?

A.—The lead on a link engine can be changed without moving the eccentrics by changing the length of the valve. For more lead shorten the valve and for less lead lengthen it.

Q.—What are some of the causes of the reverse lever rattling with a link motion when the engine is running backward or under, when it will run perfectly smooth when engine is running forward or over. Is there any remedy and what?

A.—The link block may be either too loose or too tight on the backward motion. It may be that the engine is run least on the backward motion and the link block is too tight in the link at that point. If the block is loose enough in the link, you will notice that the link has a slight motion over the block at every revolution of the engine and if the block is too tight to allow this motion it will put an additional thrust on the reverse lever.

Q.—A young man says that he set the valve on a traction engine with link reverse and when the engine was on center and the valve had one-eighth inch lead with reverse lever in last notch, and when moved up to center notch it had one-fourth-inch, and he says the valve was set right. What is your opinion? Engine had the same lead at both ends on either center, but when the lever was brought to the center notch it increased the lead one-eighth inch.

2.—Can the lead be changed on a single eccentric reverse after it leaves the factory? If so, please explain.

A.—The link has a radius equal to the length of the eccentric rod, but since the center of the eccentrics are not with the center of the crank shaft the link does not run exactly true with the shaft, so that every link changes the lead of the valve somewhat at the different points. For an ordinary size engine this lead is too much. One-half of this amount would be sufficient.

2.—The lead can be changed on a single eccentric valve gear by changing the length of the valve.

Q.—If you set a valve, link reverse, with equal lead, will it have equal cut-off?

A.—A link valve gear set with equal lead will not have an equal cut-off, especially if it has a slide to guide the valve rod. A rocker arm, such as is used on a locomotive can be adjusted to correct this discrepancy.

Q.—Why does the link on my engine run perfectly quiet under the belt or going backward, but going forward it rattles and shakes reverse lever in quadrant?

A.—Your link evidently fits too tight at one end and possibly too loose at the other. In most links the link works up and down over the block while the engine is running. This motion is not very much, but if it is held rigid by the block fitting the link too tightly, the motion will come to the reverse lever and make it work in the joints.

Q.—How shall I set the eccentrics on an engine, center crank, link reverse and each eccentric independent of the other.

The engine I am running has a link motion. One of the eccentrics slipped on the shaft. Is there any rule for setting them?

A.—The first thing to do is to divide the valve. Throw the reverse lever to the extreme end of the quadrant. Now turn the eccentric (which is connected to the end of the link which is in line with the valve rod) to one end of its travel. Note the port opening, then turn the eccentric to the other extreme and note the port opening on that end. Now move

the valve so that the port opening will be the same on both ends. Then place the reverse lever at the other end of the quadrant and see if the port opening is the same on both ends. If it is not, the adjustment should be made on the eccentric rod. After this the engine is put on dead center and the eccentric moved in the direction indicated by the reverse lever till the the valve opens the port at the end in which the piston is located. Now place the reverse lever to the other end of the quadrant and turn the other eccentric in the direction the reverse lever calls for till the valve opens the proper amount for the lead on the end of the cylinder where the piston is located. The eccentrics are now set. The engine may be turned to the other center to see that the proper lead is on that end also, and in case of any discrepancy in the work it can be corrected by going over the form again.

To simply set a slipped eccentric, put the reverse lever at the end that will bring the eccentric rod in line with the valve rod, put the engine on dead center, and proceed to turn the eccentric the direction indicated by the reverse lever till the proper lead is obtained at the end of the cylinder at which the piston is located. Turn the engine over and watch the port opening, running both forward and backward to see that you have not made any mistake.

Q.—Should not the eccentrics on a Nichols & Shepard engine be exactly opposite one another? My reverse jerks, and I thought that was the trouble. The engine is quite old.

A.— The eccentrics should not be opposite to each

other on your engine. If you want to see if they are in their place, you can examine the valve, and if it has the proper lead on each end, your eccentrics are all right; however, you don't need to go to that much trouble. An experienced man should tell by the exhaust of the engine if the valve is working right, or if the eccentrics are in their proper place. You no doubt have some looseness about the reverse motion. Plenty of cylinder oil is the best remedy for troubles of this kind.

Q.—What is the cause of my engine exhausting heavy on one side and the valve stem throw into the steam chest quick and then pull out slow and do the same thing reversed. The eccentrics are keyed to the main shaft and the cams are properly divided so as to divide the travel of the valve even, but it does it by drawing the stem out slow and pushing it back quick. What is the cause and what is the remedy? When I put my single cam on I get an even exhaust and the stem of the valve travels even, but when I put the link on it throws it all off.

A.—If your eccentrics are keyed to the shaft you should not have any trouble in getting the balance of the gear properly adjusted. Throw the reverse lever to the end of the quadrant for the forward motion, see that the reach rod is of proper length so that the link block goes to the end of the link, then adjust the valve so that you have the same amount of lead at each end. Now reverse the engine throwing the reverse lever to the end of the quadrant and see that you have again the same amount of lead at each end

of the valve. The valve should not be moved on the stem in setting for the second motion, but all adjustment should be done by the eccentric rod.

Q.—How do you set a Russell valve?

A.—A Russell or Giddings valve is a double ported and double D valve. There are two exhaust ports in the cylinder to match the two exhaust cavities in the valve. However, it takes steam on the end like a common D valve, yet the ends of the valve proper cannot be seen when the valve is in its place, there being a cover over the valve which forms a steam chamber, thus there is no chance to see the ends of the valve proper nor the cylinder ports. There are marks on the bottom of the steam chest which correspond to the ports in the cylinder, also marks on the back of the valve which correspond to the end of the valve where the steam is admitted. Thus the valve can be divided; that is, the same amount of lead can be had on each end by shifting the valves. There being a right-hand thread on the one end of the rod and a left-hand thread on the other. The eccentric is keyed to the shaft and never needs any attention.

If the engine is of the simple type, the valve can be set by the sound of the exhaust. The valve stem can be turned while the engine is at work, and by turning the stem the proper place of the valve can easily be found by observing the sound of the exhaust. The low pressure valve of a compound engine can also be set by the sound of the exhaust.

Another easy way to set a Gidding's valve is to take the plugs out of each end of the cylinder (these

holes are provided for the indicator) then run the engine allowing the steam to blow out the holes. Now hook the reverse lever as close to the center notch as possible, and if the valve is not properly set, you will find one end will blow harder than the other. There are means on the valve rod to adjust the valve without taking off the steam chest cover. You will find this method perfectly satisfactory as it can be set in this way as accurately as with an indicator.

Q.—Please inform me how to set the piston or balanced valve used on the Peerless traction engine. Please do not say it is done by indirect measurement. I would like to have the details.

A.—Aside from measurements and the aid of an engine indicator there is nothing so effective as setting a valve by the sound of the exhaust. When both ends of the cylinder sound alike the valve is properly set, as far as the cut-off is concerned, and as all valve gears of the type mentioned have the eccentric fixed on the shaft so that it cannot be changed, there is only the cut-off to adjust. Move the valve and note the results. You will soon find whether you have made it better or worse, and the case will suggest how to move it till properly adjusted.

Q.—Will a balanced valve develop enough more power or make saving enough over a plain slide valve to pay the expense of putting one in an engine?

A.—A balanced valve which does not leak any more than an unbalanced one (other conditions being equal) will certainly have the advantage, as the

power which it takes to run the unbalanced valve can be used on the load of the engine.

The unbalanced valve has a tendency to wear to its seat and keep tight, but the balanced valve is apt to become leaky and hard to keep steam tight, and the saving in power which it takes to run it is lost in the amount it leaks more than the unbalanced valve. However, if the balanced valve is kept steam tight, either by adjustment or renewing the parts, it will enable the engine to give off more power. Whether it will pay to make a change of this kind depends on what kind of a valve it is changed from and what kind it is changed to, as there are some balanced valves which are not as good as a common D unbalanced valve.

Q.—What is the remedy for a valve that, after the reverse is put in the center notch and steam admitted, will make two or three revolutions one way and then make two or three the other way, and keep on reducing the number of revolutions until it finally stops? The valve is a piston valve.

2.—How can a piston valve seat be case hardened; and what kind of composition would the editor advise for rings of such a valve?

A.—Reduce the lead of the valve. This lead may be all on one end, due to shifting the valve one way, or if not, the valve lead should be changed by shifting that part of the valve gear that will accomplish it. A leaky valve will sometimes have the same effect.

2.—A piston valve seat cannot be hardened when

cast in one piece with the cylinder. Cylinders are usually made of close grained hard iron. The only means of hardening the seat would be to use a bushing which can be hardened to any degree and then ground to a fit and pressed in place. The valve rings or piston rings should be of good cast iron, not too hard.

VALVE GEAR—MARSH.

Q.—Can you tell how to set the valve correctly on an Advance engine (Marsh reverse). I want to babbitt the reverse boxes and I will have to set it over. Tell me in a plain way.

A.—Get the engine on the center, placing the crank pin toward the cylinder, then place the reverse lever in the center notch, then turn the reverse gear on the crank shaft until the crank pin of the reverse gear shaft is on its center nearest the crank shaft or away from the cylinder. This position you estimate by eye. Then tighten the screws in the reverse gear on the crank shaft slightly and temporarily. Then as a preliminary in the operation set the screws that are in the top and bottom of the stop plate so they will project inward about one-half inch from the lugs on the stop plate, though it is not important that they should be set exact, as this is not the correct and final position for them. Then move the reverse lever down until the reverse box strikes the screw in the bottom of the stop plate, and fasten the reverse lever in that position. Now, with the engine still on the center nearest

the cylinder set the valve on the valve stem with the edge of the valve even with the edge of the port in the valve seat, or so that the valve just covers the port, then tighten the screws slightly that hold the valve to the valve stem. Then, with the engine still on the same center, move the reverse lever in the opposite direction until the reverse box strikes the screw in the top of the stop plate, and fasten the lever in that position. If the edge of the valve does not return to the edge of the port, or if it laps by the edge of the port, make a mark on the valve seat even with the edge of the valve. Now make another mark half way between the edge of the port and the first mark, then loosen the screws in the reverse gear on the crank shaft and turn the gear until the edge of the valve stops at the center mark just made. Now tighten securely the screws in the reverse gear on the crank shaft. After this operation the gear is supposed to be properly located.

The next step in the operation is to loosen the valve on the stem and set it so there will be about one-thirty-second of an inch opening between the edge of the valve and the port; this is what we term the lead, and the valve should now be securely fastened on the stem while in that position, the engine still being on the center nearest the cylinder. The next step in the operation is to place the crank pin of the engine on the opposite center or away from the cylinder. The reverse lever being in the top notch the engine should be turned over in centering it. It should be turned in this manner in order to take up the lost motion in

the reverse gear. The engine is thus centered to determine the lead on the opposite end of the cylinder. With the reverse lever still in the top notch, if the lead is found to be more than one-thirty-second of an inch, turn the set screw into the lug at the top of the stop plate until the proper lead is secured. If it is found to be less than one-thirty-second of an inch, turn the set screw out of the lug at the top of the stop plate until the proper lead is secured. Having thus secured the proper lead the jamb nuts on the set screws should be securely tightened.

Q.—How can I get the slide valve in my engine steam tight?

A.—Slide valves and seats are made steam tight by scraping them to a true surface with a scraper, according to the indications of a true surface. The valve and face should be trued up separately. The valve is scraped first in the following manner: Take a little red lead or lamp black mixed with a little oil, and smear it over the surface of the surface plate with your fingers, wiping it nearly dry with the palm of your hand. Then slide the valve over the surface plate and wherever the dressing on the surface plate rubs off on the valve face it should be scraped down, as the marks on the valve face indicate the high places. Continue this operation until the spots become close together and get to be quite a number of them. It is not safe to have a large spot on the valve which you cannot mark by rubbing it on the surface plate, as it may be quite hollow at the spot. When

the spots are close together it follows that the places between the spots cannot be very low.

After the surface of the valve is thus made straight the valve seat is treated in the same manner, by using the valve to mark the seat instead of the surface plate used to mark the valve. Rub the dressing (oil, or red lead or lamp black) on the valve and slide the valve over the seat in the same way it is moved by the eccentric and proceed to reduce the high places with a scraper indicated by the dressing.

A good way to make a scraper is to grind off the end of a scraper and also grind the teeth of the file off at the end. The cutting edge of the scraper should not be as a knife edge, but a square edge, just like the end of a board.

Q.—Is a valve after once properly set very apt to come out of order?

A.—A valve or eccentric is apt to slip, if they are not properly secured, but in some engines the eccentric is keyed to the shaft and the valve is so securely fastened that it is almost impossible for it to get loose. Yet in all engines the valve gets out of place in time, due to the wear in the bearings of the engine. This, however, should not affect the valve to any marked degree within a few years of work. Some engines will need attention in this respect sooner than others and whether or not it needs attention can always be noticed by the exhaust. If the exhaust is square your valve is likely all right, but if it is "lame," or louder on one end than the other, it should be looked after,

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and usually the only thing that is needed in this case is simply the shifting of the valve.

Q.—There is something wrong with the valve gear of my engine. When I place the reverse lever in the center notch while the throttle valve is open, the engine will continue to run. If I reverse the engine and again place the lever in the center notch, it will continue to run in the reversed direction. I will say that the engine will only do this running without any load. Should it not stop when the reverse lever is in the center notch? Don't this show that there is something wrong? How can this be fixed? I sent to the factory for a man, and he went over the engine, moved the valve on the stem a trifle, set up the boxes a little and it acted all right when he was here, but in a few days I discovered that it was all wrong again. The eccentric is keyed on the shaft; do you think it should be moved? Do you think this trouble will have a bad effect on the power and economy of the engine? If so, I would very much like to know what to do for it.

A.—This is a very common freak of reversing engine with a constant lead. That is when the engine has the same amount of lead at all points of cut-off, and therefore it will have the same lead when the reverse lever is in the center notch. Therefore it opens the port when the lever is in the center notch, which fills the clearance with steam, and the expansion thereof is sufficient to run the empty engine. This is not a fault of the engine and does not show that there is anything out of adjustment. In fact,

your engine must be set very accurately, as it often happens that an engine will run one way when the reverse lever is in the center notch while the throttle is open, but when an engine will run either way under the foregoing conditions, it shows that the rod connecting the reverse lever to the valve gear proper must be of the correct length.

If the eccentric is keyed to the shaft, this shows that it is in the place which the builder intended it to be. The fact that the engine did not run when the throttle was open and reverse lever in the center notch after the man from the factory adjusted it shows that he made one or more of the boxes tight enough to make enough friction to prevent the engine running with the little steam which the engine gets with the reverse lever in the center notch. Tight stuffing boxes will make enough friction to hold an engine under such conditions. The fact that it runs so easily shows that it must be will lined up and in good condition generally, also well oiled.

Q.—I have a complete Russell outfit 20 h. p. 9 x 13 engine, 1903 make, 40 x 60 separator, Case feeder, Perfection weigher, as good rig as there is in the country.

Engine uses about 35 bbl. of water a day, 1200 lbs. to 1500 lbs. of coal a day, careful firing. But valve clicks rather hard, seems to me there isn't enough back pressure, would it harm if those two little holes in bottom of valve be made 1/32 inch larger so as to keep valve on seat better? I put one

inch washer in spring pocket, which gave but little relief.

A.—In answering it may be best to explain that the valve in this engine is in reality a moving steam chest, wherein the live steam is within the valve and just enough pressure is supposed to be maintained in the steam chest to keep the valve from leaving its seat.

It has been found by experiment that it requires 45% of the steam pipe pressure in the chest to keep the valve to its seat.

Now it is clear that if any leaks occur that tend to reduce this pressure, the valve will leave its seat and slap and large leaks will be the result.

The little drain cock under the chest may be leaking and this would reduce the pressure. Or sometimes the engineer is careless in packing his stuffing box and a leak will occur around the valve stem from this cause, which of course reduces the pressure in the steam chest and causes the valve to slap and leak.

If these two causes are looked after and remedied the chances are that the valve will stay to its seat and the leakage complained of will be stopped unless, indeed, the valve has been allowed at some time or other to become dry and scored on its surface, as well as that of the valve seat. The remedy for this defect is re-scraping of the valve and seat.

Q.—Which is the proper way to set the valve and eccentrics on a Star engine, with link reverse? Please give full detail of setting the valve, and the true way

of getting the off center up and down, are there any by measuring on slides?

A.—Place the reverse lever in end notch so that block is at end of link, divide the valve by turning eccentric from one extreme to the other, then set crank pin on center and move eccentric in advance of crank pin till proper lead is obtained, now place reverse lever in the other end notch and turn the other eccentric in the opposite direction to the former in advance of the crank pin till the proper lead is obtained. This will place both eccentrics and give equal lead on each end but not an equal cut-off due to the angularity of the connecting rod. To get an equal cut-off (providing you have given 1/16-inch lead) shift the valve so that you get 1/32-inch on cylinder head and 3/32-inch on end toward the crank. This will tend to equalize the cut-off which is of more importance than the lead. A rule for finding the center of the engine is given with illustrations elsewhere in this book.

Q.—With the wrist pin set on the dead center and the valve set with one-sixteenth outside lead how much should the inside lead be for best economy of steam? Engine 20 h. p., runs 240 revolutions per minute.

A.—On a 20 h. p. engine under average conditions the slide valve would have about one-sixteenth of an inch inside lap on a simple engine and one-eighth of an inch inside lead on a compound engine. The reason for having more opening for the exhaust on a compound engine is that the receiver pressure is

greater than the back pressure in the simple engine and would get the compression too high in the high pressure cylinder, and in the low pressure cylinder the initial pressure is so low that if it would start to compress as soon as the simple engine the compression would get above the initial pressure.

Q.—I have a Woolff compound engine that runs nice and smooth with 100 lbs. of steam or less; when it gets above 100 lbs. it jerks and pounds on the reverse gear; especially so with a light load. What is the cause and how can I remedy it?

A.—A lack of cylinder oil is often the cause of a hard running valve gear. The increased pressure makes the valve run harder, due to extra load. There may be some worn parts in the valve gear and the extra load will cause it to "jerk" or rattle. It is likely that if you take up all lost motion in your valve gear and use a good quality of cylinder oil and plenty of it you will get your engine over its trouble.

Q.—When my Woolff reverse gear is hooked up to one-half or three-fifths it will run smooth, but hook it out to three-fourths or full cut-off, it will jerk the reverse lever in the quadrant as if it would break it. What is the cause?

A.—When a Woolff gear is cutting off at a late cut-off the reversing guide or link is at a more obtuse angle to the eccentric than when it is cutting off at an early cut-off. Notice when you have the reverse lever in the center notch the guide is vertical and offers little resistance, but as the cut-off is increased the angle of resistance becomes greater and therefore

makes it work harder. Plenty of oil to the slide valve will help this "jerk."

Q.—Will you please inform me in what position the eccentric ought to stand when the crank shaft is on center, and in what position ought the crank shaft to stand when the exhaust escapes?

A.—In a Woolff valve gear the eccentric is opposite the crank pin. In a link valve gear the eccentrics are about 120° from the crank pin, one in each direction. In a shifting valve gear or reverse gear when the eccentric moves across the shaft to vary the cut-off the angle of the eccentric in relation to the crank pin changes as the eccentric is shifted. In any case the position of the eccentric depends on the lap of the valve. The exhaust should occur at about seven-eighths of the stroke of the piston. This point changes with the cut-off in a single valve engine. The later the cut-off the later the exhaust, the earlier the cut-off the earlier the release or exhaust.

Q.—Is the Woolff valve gear perfect? If so, why will the engine run with lever in center notch?

A.—We hardly think there is anything perfect about machinery. When a Woolff gear is in proper adjustment it comes very close to perfection. If your engine only runs one way while reverse lever is in center notch, this would indicate that the rod running from the reverse lever to the reversing shaft, is either too long or too short; but if the engine will run both backward and forward while reverse lever is in center notch, this will indicate that the valve has too much lead. However, the latter is hard to fix in this

class of valve gear and will do no harm, and the former case can be easily fixed by simply changing the rod mentioned.

Q.—I have a Woolff gear that shows the same lead with the reverse lever in any position, but I can't get the valve to travel the same when lever is forward; the front port opens full and back port lacks about one-fourth of an inch of opening full. When lever is thrown back the back port opens full and the front port lacks about one-fourth of an inch of opening. I have an adjustable reverse rod and have tried it with many different lengths, but can't get it to travel equally. Should the Woolff exhaust alike on both sides? One engineer says it should, while another says it does not and can't be made to.

A.—If your Woolff valve gear is set with equal lead you have it set to the best advantage. It is the nature of the mechanism to open one port wider than the other. The point which is made in this gear is to have a very near uniform cut-off. The end which has the smallest port opening has the latest cut-off and the port which has the largest port opening has the shortest cut-off. Thus making the work done on each end of the cylinder about equal.

Q.—Suppose an engine fitted with a Woolff valve-gear has too much lead; how is this remedied?

A.—The easiest way to reduce the lead on a Woolff valve-gear is to make the valve longer. There is another way to accomplish this, but it is more troublesome.

Q.—Is the reverse block to the Woolff reverse exactly over the crank shaft, and if not, why?

A.—The reversing shaft is usually set directly over the crank shaft, yet this is not essential, as it may be set a few degrees off the vertical center line, providing the eccentric is set the same number of degrees off the center line drawn through the crank pin and crank shaft.

Q.—Why don't threshing machine manufacturers build automatic engines? Why could not such an engine be built in connection with Woolff valve gear, so they could be reversed as readily as simple engines? I do not see why they would be much more expensive to build because they would not require a throttling governor. They would be more economical. Some engines I think require more fuel than they ought to use for the power furnished.

A.—In the first place the engine would be more expensive. It would be also harder to keep in order. Simplicity is the thing sought for in the building of a traction engine. However, the day may come when traction engines will have an automatic cut-off. There are already automatic, reversing valve gears worked out but not as yet on the market.

Q.—In the question of G. W. S. in the December number it was stated that the common D slide valve would be lifted from its seat in case there was more water in the cylinder than the clearance would hold. Now, in order that the valve may be lifted from its seat the pressure must be raised high enough in the steam port so that the pressure multiplied by the area

of the port will equal the pressure in the steam chest multiplied by the area of the back of valve plus the friction of raising the valve. Would not that pressure break the cylinder head?

A.—In slide valve engines the cylinder and cylinder heads can be broken, due to water shocks, when they are weak, but if properly proportioned they will stand the pressure required to drive the valve from its seat and thereby allow the water to escape from the cylinder. The pressure in the cylinder has to be from 25 to 50 per cent. in excess of the pressure in the steam chest to drive it from its seat. This acts as a safety valve to the cylinder. In case of a piston or a pressure plate valve with no provision for the latter to lift from its seat, the general practice is to have relief valves made somewhat on the plan of a pop safety valve, to insure the safety of the cylinder and other parts which are affected by the water shock.

CHAPTER IV.

HORSE POWER.

Q.—How was the standard for h. p. rating established?

A.—The first application of the steam engine as a substitute for horses was in hoisting coal from mines. James Watt found the best English draft horse would raise a weight of 150 lbs., walking at a pace of two and one-half miles per hour, or 220 feet per minute; hence $150 \times 220 = 33{,}000$, or the same thing, 33,000 lbs. raised one foot per minute. This duty is the recognized English standard of the indicated horse power (h. p.) as applied to steam engines, and recognized by all engine builders in the United States. It follows that an engine having a piston of 10 square inches area, working with a mean effective pressure (m. e. p.) of 15 lbs. ($10 \times 15 = 150$) would be equal in strength to that of a horse raising 150 lbs. and a piston speed of 220 feet per minute ($10 \times 15 \times 220 = 33{,}000$) is the equivalent of the work done by the horse. Or in modern traction engine practice, a piston having 1½ square inch area, working with a m. e. p. of 55 lbs., and a piston speed of 400 per minute ($1.5 \times 55 \times 400 = 33{,}000$) would also be equivalent to the work done by the horse.

Q.—What is meant by mean effective pressure?

2.—How do you get it?

A.—Mean effective pressure means the average pressure exerted on the piston throughout the entire stroke of the engine.

2.—Mean effective pressure is arrived at by the aid of the engine indicator, which records the pressure at all parts of the stroke, with a pencil on a card.

Q.—In finding the h. p. of an engine how do you find the nearly exact mean effective steam pressure on the square inch of the piston, without the use of an indicator? For instance, when there is a steam pressure in the boiler of 130 lbs. per square inch. I have tried to figure with one-third of actual boiler pressure, but my figures do not correspond with those of engine builders.

A.—One-third of the boiler pressure is a good rule to arrive at the approximate mean effective pressure. This will be an attempt at the actual rating. The nominal h. p. rating, such as given in the catalogues of traction engines is about one-half of the actual h. p. rating.

Q.—I would like to have you send me, if you will, the rules for finding the h. p. of an engine.

A.—The rule for figuring the h. p. of an engine is to multiply the area of the piston in inches by the piston speed in feet per minute by the mean effective pressure and divide by 33,000; this will give the indicated h. p. The mean effective pressure is arrived at by the aid of the indicator. To arrive at the nominal h. p. as used by traction engine builders in this

country a mean effective pressure of 20 lbs. can be used.

The heating surface of a boiler is computed in square feet. To compute the surface in the tubes multiply the circumference in inches of the outside by the length and by the number of tubes, and divide by 144. This will give the area in square feet. Find the area of each sheet in the firebox above the grate line, deduct the flue holes and fire door hole, also the front tube sheet. Reduce this also to square feet. After having the total surface in square feet, divide by, say, 12, which will give the h. p. Some builders give 10, some 11, some 12, and some 13 square feet of heating surface to the h. p.

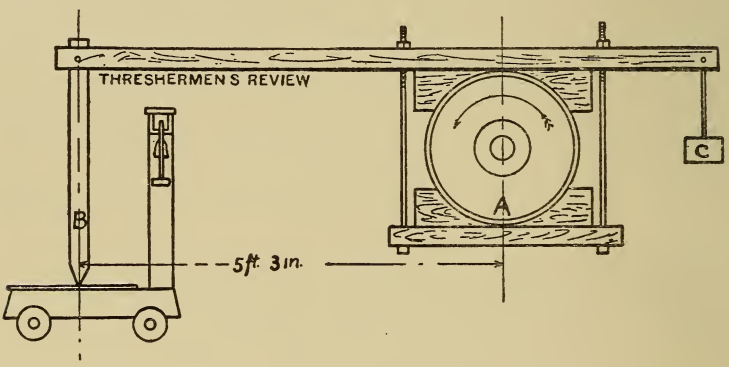
Q.—How can I find the power of an engine without an indicator?

A.—An engine indicator or a dynamometer is necessary to find the amount of power which is used to run a certain machine; but if the maximum power of an engine is required, the Prony brake will answer the purpose very well. The difference in results is that the indicator gives the power developed in the cylinder, which is more power than the dynamometer or the brake will show. The difference is caused by the friction of the engine which is 10 or 15 %. Brake h. p., or power measured by a dynamometer, is known as available h. p.

A Prony brake can be very easily constructed. The accompanying drawing shows how one can be made. The bolts are drawn up till the desired load is obtained and the pressure is then weighed on a scale.

C, is a weight used to counterbalance the beam, so that when everything is at rest, the beam rests on center, *A*, and there is no pressure on the scales.

There are two ways in which the h. p. of an engine can be figured. If the distance from *A* to *B* is not as per drawing the following is necessary. The distance from *A* to *B* in feet, multiplied by 2, multiplied by 3.1416, multiplied by the pressure on the scales, mul-



tiplied by the revolutions per minute, and divided by 33,000, equals the h. p. This is the regular rule. But when the distance from *A* to *B* is 5 feet 3 inches, the problem can be very much shortened, thus; Pressure on scales multiplied by revolutions per minute and divided by 1,000 equals h. p. This applies to gas engines as well as steam engines, and to motors of all kinds.

Q.—Should a traction draw as much as its rated h. p., say attached to plows?

A.—Three horses can pull a gang of two plows, which would be one and one-half horses to each plow. It will take about one and three-fourths h. p. nominal to each plow. This statement is based on the work done by a 25 h. p. engine.

Q.—Which engine would develop the most power, one with a cylinder 8¼ x 10 with a balanced piston valve, the other 8¼ x 11 with a common slide valve and locomotive link reverse?

A.—All other things being equal the larger engine would develop the most power. While the piston valve would run easier it would not make as much difference as one inch on the stroke of the engine. The difference in the power would be about 1½ h. p. (nominal) in favor of the larger engine.

Q.—Kindly advise me which of the following is the stronger engine and give the horse power of each, viz.: 4½ x 8 cylinder, 36-inch flywheel, 270 revolutions per minute, 100 lbs. boiler pressure; 5 x 6 cylinder, 33-inch flywheel, 215 revolutions per minute, 100 lbs. boiler pressure. What would be the power of the 5 x 6 at 270 revolutions?

The 4½ x 8 engine has a connecting rod about four inches longer than the 5 x 6. Would this make any difference in the power?

A.—A reasonable mean effective pressure for 100 lbs boiler pressure would be 35 lbs. The 4½ x 8 engine running at 270 revolutions per minute will develope 6 h. p.; the 5 x 6 engine running at 215 revolutions per minute will develope 4½ h. p., and the

latter engine running at 270 revolutions per minute will develope a little more than 5½ h. p.

The longer stroke engine should have the longer connecting rod. This, however, will not make any difference in the power.

The size of the flywheel does not influence the power of the engines, as the source of power is in the cylinder. However, the flywheel can be so out of proportion that the power of the engine is poorly applied. For instance if the flywheel is too large for the drive pulley on the machine, which is run by the engine, then the speed of the engine has to be cut down and the power is cut down in proportion.

Q.—If a 10 h. p. engine has a 14-inch pinion on main shaft, will one with a 7-inch pinion make a 20 h. p.?

A.—Simply changing the size of the pinion on crank shaft will not change the power of the engine. With a given number of revolutions of the crank shaft and with the pinion on crank shaft reduced to one-half the size, the engine will pull twice the load, but it will also take twice as much time to do it in, and the horse power will be the same. But by reducing the drive pinion to one-half the size and running the crank shaft twice as fast, the power will then be doubled.

Q.—Which of the following engines will show the most horse power under belt? A Woolff tandem compound, high pressure cylinder being 6½ inches diameter by 10 inches stroke, and low pressure being 9¾ inches diameter by 10 inches; mean effective

pressure 150 lbs., 220 revolutions per minute, and flywheel being 40 inches diameter by 10-inch face, or a double valve tandem compound having the cylinders separated for the stuffing boxes with high pressure cylinder 6½ inches diameter by 10 inches stroke, and the low pressure cylinder being 10 inches diameter by 10 inches stroke, mean effective pressure being 155 lbs., 225 revolutions with a 36-inch flywheel by 10-inch face.

A.—Figuring the case with the same number of total expansions in each engine the latter engine would develop 12 % more power than the former; due to the increase in diameter of low pressure cylinder and also to increase in speed and pressure.

The mean effective pressure given is much higher than is found in traction engine practice.

Q.—In looking about for a 20 h. p. engine and studying the different catalogues I was considerably bothered. They ranged in stroke from 10 to 13 inches and in diameter from 8½ to 10 inches in single engines. It seems to me there must be considerable difference in power of these engines. I understand that speed and pressure make quite a difference, but would like to know the relative power of a number of 20 h. p. engines figured at the same speed and pressure. Here are all the sizes of 20 h. p. engines I could find: 10 x 10, 8¾ x 12, 9¼ x 11, 9 x 10, 9 x 12, 8⅞ x 12, 10 x 10¼, 8¾ x 10½, 8½ x 12½, 9x13, 10x11, 9½x10, 8¾x10, 9x11, two 6¾x10¼ and two 6½ x 12. Say the 10 x 10 engine is 20 h. p.,

and figure them all at that rate, that is, at the same speed and pressure.

A.—It is not exactly fair to figure a lot of engines at the same rate, as some engines are designed to carry a higher pressure and some to run faster than others. However, we can make a comparison of the sizes. The 20 h. p. is, understand, nominal rating and if we consider the 10 x 10 engine 20 h. p. the 8¾ x 12 is 18½ h. p.; the 9¼ x 11, 18½ h. p.; 9 x 10, 16 h. p.; 9 x 12, 19½ h. p.; 8⅞ x 12, 19 h. p.; 8½ x 12, 17 h. p.; 10 x 10¼, 20½ h. p.; 8¾ x 10½, 16 h. p.; 9 x 13, 21 h. p.; 10 x 11, 22 h. p.; 9½ x 10, 18 h. p.; 8¾ x 10, 16 h. p.; 9 x 11, 17½ h. p.; two 6¾ x 10¼, 18½ h. p., and two 6½ x 13, 20 h. p.

It will be seen that there is five nominal h. p. difference between these engines. The largest one may be the slowest in speed and carrying the lowest pressure and the smallest may run the fastest and carry the highest pressure, thus making the power about equal.

Q.—Which will give the most power, an engine with a 8½ x 10 cylinder running 240 revolutions per minute, or an engine with a 8 x12 cylinder running 220 revolutions per minute?

2.—Which will give the most power; an engine with 8 x 8 cylinder running 250 revolutions per minute or an engine with a 7¾ x 12 cylinder running 220 revolutions per minute?

A.—The 8½ x 10 engine running 240 revolutions per minute will give 2½ % more power than an

8 x 12 engine running 220 revolutions per minute, both having the same mean effective pressure.

2.—The 7¾ x 12 engine running 220 revolutions per minute will develop 23¾ % more power than an engine 8 x 8 running 250 revolutions per minute, both having the same mean effective pressure.

Q.— Will an engine 7 x 10 with a balanced valve give as much power as an engine with old style valves, 7½ x 10 cylinder?

A.—All conditions being equal, the larger engine will give over 12 % more power than will the smaller engine. The difference in the power of the larger engine will more than make up for the difference in the working of the valves.

Q.—Which will consume the most steam doing 20 horse work, simple 9 x 10, or compound 7¾ x 10 and 11 x 10, and which engine would require the larger boiler?

A.—Both engines being well designed and in good condition the compound engine will do 20 h. p. (nominal) with about 20 % less steam than the simple. Both engines will take about the same size boiler to supply steam to work to the full capacity of the engine. The compound engine being of about 25 % more capacity than the simple engine.

Q.—Which of these two engines will give most power to a separator, same to be run at a certain speed by either engine? One engine is 8¾ x 10-inch stroke with 38-inch band wheel. The other engine is 8¼ x 11-inch stroke with 42-inch band wheel.

A.—If the two engines have the same conditions

in the separator and the engines having the same mean effective pressure and at the same speed, the 8¾ x 10 may be called 16 h. p., and the 8¼ x 11 would be 15 h. p.; but since the 8¼ x 11 has the larger flywheel, which would reduce the speed of the engine, and this would make it 14 h. p.

Q.—What horse power is an engine 7½ x 10, 220 revolutions, 120 lbs. pressure?

2.—Is the boiler too small for the engine? It has 32 two-inch by 66-inch flues; diameter of boiler, 26 inches; grates 36x21; height above grates, 30 inches; has a water front.

A. In the absence of the mean effective pressure we cannot figure the horse power, as the boiler pressure does not indicate this. We can, however, consider the nominal horse power of the engine based on general practice in this country, as there is no rigid rule for figuring the nominal horse power of a traction engine. Manufacturers differ on this point and we find that the rating of this engine, in the hands of different builders would vary from 11 to 13 h. p.

Engines are not run under the same conditions. Speed, pressure, and cut-off, as well as size, have much to do with the power. Some manufacturers count on high speed, late cut-off, and high pressure, so that they can sometimes develop as much power with a small engine, as with a larger engine with moderate pressure, early cut-off and slower speed. It can be readily seen that nominal horse power does not indicate the exact amount of power to expect from an engine.

2.—Boilers should be considered by the number of

square feet of heating surface. In simple traction engine boilers built in this country we find from 10 to 13 square feet of heating surface to the nominal horse power, so that the boiler described in your question would be from 11 to 13 nominal h. p. The power of a boiler is also very indefinite, as it largely depends on the rate of combustion, or in other words, on how much heat is furnished.

Q.—I have an engine called 16 h. p. with 8 x 10 cylinder and 45-inch flywheel or belt wheel; another party has one called 12 h. p. with 8 x 8 cylinder and 36-inch flywheel. Now how much difference is there in the two engines with same amount of boiler pressure and properly speeded to a seven-inch cylinder pulley to run cylinder 1,200 revolutions per minute? In my opinion the 8 x 8 will develop nearly or quite as much power as the 8 x 10 cylinder.

A.—The 8 x 10 engine with flywheel 45 inches in diameter would run 186 2/3 revolutions per minute. The 8 x 8 engine with flywheel 36 inches in diameter would run 233 1/3 revolutions per minute. This speed on both engines will run the separator 1,200 revolutions per minute with a seven-inch pulley on the cylinder shaft. With the proper boiler capacity in each case and with the same boiler pressure and mean effective pressure these two engines will develop the same horse power.

Q.—Does a heavy flywheel give more power to an engine than a light one, and how can one tell when it is heavy enough? Agents from two different companies do not agree on this point.

A.—The flywheel does not give any power to the engine. The heavier the flywheel the more power it takes to run the engine. You can imagine a flywheel so heavy that the engine could not turn anything more than its own flywheel.

A flywheel should be heavy enough to carry the engine over the center well in starting, and in case of sudden loads it should have sufficient weight to maintain a practically uniform speed. The theory of a heavy flywheel is that when it is in motion there is a certain amount of energy stored up in it that can be given out again.

The harder the engine has to pull to start the flywheel and the longer it runs after the steam is shut off the more power it could give off in case of a sudden load. Very often a shock of very short duration comes on the engine, which is beyond the capacity of it and would stop it completely, were it not for the flywheel, and, if it is of sufficient weight so that the necessary power can be stored in it, the flywheel will carry the engine over so that there is no perceptible change in the speed. There is no fixed rule for the weight of a flywheel. It depends on the speed and the kind of work the engine is to do. The heavy threshing cylinders used nowadays help the engine flywheel in its work.

Q.—How is boiler horse power determined?

A.—The question of boiler horse power may be divided into two parts. First: "The term boiler horse power means capacity to evaporate 30 lbs. of water from 100° F., temperature of feed water, to

steam of 70 lbs. gauge pressure, or 34.5 lbs. from and at 212° F.," centennial standard.

Another way to compute the horse power of a boiler is by the amount of heating surface it has. In general practice 12 square feet to the horse power is standard. This too may vary among the different builders of traction engines. Some give more and some less.

The way to compute the heating surface of a traction firebox boiler is to measure the surface in inches in the firebox above the grates, subtract the area of all the tubes and fire door, multiply the circumference of all the tubes by their length in inches and in most cases the front tube sheet is also taken into account, which is the area of all the tube holes subtracted from the area of the tube sheet in inches, which when added to the tube and firebox surface and divided by 144 equals the heating surface in square feet.

A return flue boiler is computed in a similar manner: the circumference of all the tubes and fire flue multiplied by their length, added to the surface of the heads that is exposed to the heat, deducting the tube and flue holes, all in square inches, and then divided by 144 gives the heating surface in square feet, and this divided by 12 will give the rated horse power of the boiler.

The regular working pressure is generally used in testing engines under the brake.

Q.—Suppose a 16 h. p. engine running some machine not requiring much power, hooked up as far as

possible and still able to do the work on 60 lbs. of steam, or even less. Take a hay press, for instance. Now, will 60 lbs., 90 lbs., or say 130 or 140 lbs., as the case may be, be the most economical in fuel and water? This is overdrawn, but merely to illustrate the point in question.

A.—If the valve gear is hooked up as far as the mechanism will permit, and under these conditions run the machinery at 60 lbs. steam pressure, there is no advantage (from an economical standpoint) to carry a higher pressure, but rather a disadvantage, as there would be more heat carried in the boiler, than can be used, hence the loss will be greater. The reason for this is if 60 lbs. of steam pressure is sufficient to run the machinery with the foregoing conditions, the governor in maintaining the speed of the engine will necessarily reduce the pressure to 60 lbs., regardless of the pressure in the boiler.

If, however, the valve gear can be hooked up farther than the point where 60 lbs. was used, a higher pressure would then be necessary and the economy would be better. If when carrying 140 lbs. pressure you can hook the valve gear up so that the engine just carries the load without reducing the speed, there will be a marked difference in the economy of both fuel and water.

Q.—I have an engine, simple, with a 10 x 11 cylinder and it runs 240 revolutions. The boiler pressure is 135 lb. to the square inch. It is supposed to be 25 h. p., but figuring according to my books I always get it more than again as much and cannot see

how in the world they figure. Please explain to me how to figure the horse power of an engine.

A.—The 25 h. p. is nominal h. p. and your rule likely gives you the actual horse power which is about twice as much as nominal horse power. The mean effective pressure on the piston which might be 50 or 60 lb., in your case multiplied by the area of the piston, by the stroke in feet, by two, by the revolutions per minute, and this divided by 33,000 will give the indicated horse power.

An indicator is necessary to arrive at the pressure and by the aid of a planimeter or by other means the mean effective pressure is obtained.

CHAPTER V.

BOILER FEEDING.

Q.—When an injector does not work properly what is likely to be the trouble and what can be done to correct it?

A.—Here are a number of causes for improper working of an injector:

1.—Leak in the suction pipe.

2.—Water supply cut off by strainer on suction pipe getting clogged.

3.—Loose lining inside of suction hose.

4.—Leak around the stem of suction pipe valve (a common cause).

5.—Too low steam pressure for height to lift.

6.—Too high steam pressure on long lifts.

7.—Dirt in tubes, scale, iron cuttings, or red lead blown in or drawn in through steam or suction pipe.

8.—A bad check valve; one not lifting enough or not at all.

9.—Valve in suction pipe not properly regulated below the pressure at which it can be thrown wide open.

10.—Loose disc on water supply valve.

11.—Wet steam, foaming boiler, or new boilers full of oil or grease.

12. Steam pipe connection made to pipe used for

other purposes and at the same time, thus robbing the injector.

13.—Water supply too hot.

14.—Overtaxing injector beyond its capacity.

15.—Injector improperly connected.

16.—The feed pipe where it enters the boiler may be limed up.

17.—The injector may be limed up, or in case of gritty water the jet may be cut out to a larger opening.

18.—There may be an obstruction in the steam pipe, or a scale or chip in the steam jet, but, more often than anything else, a defective suction pipe or hose will cause the injector to fail.

Q.—I have an injector with three-fourths-inch connection. It will force water into the boiler very well with 70 to 80 lbs. of steam, but with from 100 to 120 lbs. of steam it will not force the water into the boiler at all—runs out at the overflow.

A.—There is only a limited range to the pressure at which an injector will work. If it works at a very low pressure it will not work at a very high pressure, and if it works at, say, 120 lbs. it will not work at the low pressure, say, 20 or 30 lbs.

The jets may be cut out due to working sandy water. If this is the case, send to the manufacturer of the injector for new jets and state at what pressure you want it to work and they will send you the proper size jets. Before you do this see that everything is clean about the injector and that the delivery pipe to the boiler is free. The fact that the injector

takes the water and delivers it at the overflow, would indicate that the suction pipe is tight.

Q.—Which is the most economical, to feed boiler through heater with independent pump or injector?

A.—The independent pump with a heater would be the most economical, as the water is pumped by a comparatively high duty engine and is heated by waste steam from the engine. It is true, when an injector is used the heat of the steam used goes back into the boiler whence it came; but in the case of heating it with exhaust steam, the heating is all gain.

Q.—My engine seems to have plenty of power, but the steam goes down in a couple of hours after steady work. The boiler is supplied by two injectors, three-fourths-inch pipe connections, with no pony pump. Would it be of any advantage to reduce the pipe connections to one-half-inch? The safety valve is set to pop off at 95 lbs.

Q.—I am running a 30 h. p. stationary engine with a 40 h. p. internally fired boiler, to pump water for irrigation purposes. My object is this. I would like to use the steam from the exhaust pipe to warm the water before I feed it to the boiler and, by doing so, save fuel. The water is good, coming from an artesian well. I pump it from a hole made in the ground outside of the buildings about six feet on the right of the engine. The exhaust pipe is on the left of the engine. I feed with an injector or a small double acting pump with brass valves. So I would like to get your advice on the following:

Can I let the exhaust pipe discharge the steam in the water?

A.—An injector will not handle very hot water, or water over 100° F., especially if it has to lift it a few feet, and after the water gets very hot a pump will not lift it. The chances are you will have trouble all around by heating the water. Your best plan will be to get an exhaust feed water heater. The principle of such a heater is usually to force the cold water through the heater and after it comes out of the heater and ready to go into the boiler, it will be much hotter than it would be if it were heated before it were pumped. However, there are heaters that heat the water by exhaust steam before it is pumped into the boiler, but this heater must always be higher than the pump so that the water can run into the pump, as the pump will not lift hot water very well.

A.—It would not be any help to you to reduce the injector connections to one-half-inch. If the three-fourths-inch injector delivers the water too fast, you can reduce the capacity of it by partly closing the suction valve. The injector can be throttled so that it can be working continuously. To reduce it to its minimum delivery, turn on the suction and steam valves full, and after it is at work shut off the suction valve until the injector "breaks," or runs at the overflow; then give it a little more water at the suction valve so that it will again deliver the water to the boiler. After the engine is running and you see that the water is getting low in the boiler, open the suction valve a

little more and after working with it a short time you will be able to set the injector at the start, so that it will keep up the water without starting and stopping it so often.

Q.—What is the matter with my Moore pump? When I start it to take water into boiler it will make a few strokes and then stop. It will pump if not pumping into boiler. That is, if I let the water run on the ground; but will start hard then, too.

A.—If your pump takes the water and will pump it on the ground, this would indicate that there must be something wrong with the discharge pipe or the pipe between the pump and the boiler. There may be a closed valve or one out of order. Examine the check valve and see that all other valves are open. It sometimes happens that the feed pipe gets entirely limed up, just where it enters the boiler. This may be your trouble.

Q.—Why does a pump only draw water a certain distance?

2.—What is the limit a pump will draw water?

3.—Which works the easier, a large or small suction pipe?

A.—No pump draws water; a pump can no more lift water than it can lift itself; it lifts nothing below its "barrel" at any time. The plunger or bucket of a pump displaces the air which is in the barrel of the pump, and exhausts that which is in what is called by custom the suction pipe. After the air is displaced from the pipe the pressure of the atmosphere pushes the water in to fill the vacuum. The pump has no

other office to perform than to get the air out of the pipes.

The size of the "suction" pipe has nothing to do with the action of the pump; it does not make the pump work one bit easier whether it is large or small. The size of the suction pipe has, however, an influence on the efficiency of the pump only, and so far as easy working of the pump is concerned, it would act just as well if it were one-inch in diameter as if it were four inches. The suction pipe should not be over 24 feet vertical from the water.

Q.—How would you test an engine with cold water?

2.—Will an injector work with anything attached to the steam pipe?

A.—If you have a crosshead pump on the engine you can fill the boiler to the top and then pump the pressure up by turning the flywheel by hand. A force pump of course is the best. It is customary to pump the water up to twice the working pressure.

2.—An injector should never be connected to a pipe in which the steam is used for another purpose, neither should steam be taken out of an injector pipe for any other purpose, as the full pressure is required to make it work well.

Q.—I have an A.-T. 12 h. p. engine and use the crosshead pump. Why is it that the higher I carry my water the less it seems to take, as I have to shut off my pump valve quite a bit more with four inches of water than I do with one inch? The engine under the same load at all times.

A.—If the water in the boiler is too high so tnat it would cause priming or foaming it would take more water than if it were lower and did not prime or foam. If the boiler will furnish dry steam, with high and low water, the engine will use as much steam in one case as the other. Any certain quantity of water will make as much steam in either case.

Q.—Can an engine be run too fast for a crosshead pump to work good? If a pump does not throw enough water how would you make it throw more?

A.—If the pump had sufficient capacity when the engine was new there is simply something out of order. The valves may be leaking. A leak in one or both valves will affect the capacity. If the suction pipe or hose is out of order, this would also reduce the capacity, either by a leak or stoppage. If the pump never had enough capacity, the best way to get more is to put a larger plunger in the pump. This will necessitate reaming out the stuffing box. The speed of a traction engine cannot be too fast doing regular work.

Q.—Can an injector be run or made to work against boiler pressure with compressed air?

2.—How is a railroad boiler filled with water out on the road?

A.—An injector will not work with compressed air. The source of power in an injector is due to the condensing of the steam which increases the velocity of the water and thus enables it to work against the pressure of the boiler which supplies the steam. Not

being able to use air in this manner it would not work at all.

2.—The modern locomotive boiler is fed by an injector.

Q.—I would like to know something about the nature and care of injectors. Mine is showing very little wear, and I cleaned it perfectly bright, but it would not work, connections all tight. I soaked it two days in concentrated lye water, and it works all right. Some said to use muriatic acid. Will either one injure it?

A.—The failure of an injector is most often caused by a defective suction hose. It not only leaks but the lining gets loose and closes the hole and prevents the flow of water. You may have the injector thoroughly cleaned but it sometimes happens that the jets get cut out by sandy water. In this case the best thing to do is to send to the injector factory for a new jet. There are also valves that may become leaky which may cause trouble.

Q.—What makes a crosshead pump pound and jerk the pipes as though it would jerk them in two? Sometimes hard to get started, also. Please advise me what to do for pump and what is wrong.

A.—The fact that the water is forced into the boiler by impulses will naturally make a jar in the pipes. The faster the engine runs the more intense the jar. An obstruction in the suction pipes which will allow the pump barrel to become only partially filled with water will make the jar more intense, as the water is started by the plunger when at a higher

rate of speed than at the beginning of the stroke. This may be your trouble.

Q.—When one is pulling his load up a hill and is pulling the engine hard, and the steam goes to escaping from the pop valve is it an injury to the flues to drop the dampers tight so the steam will not escape?

A.—It does not harm the flues to check the draught by shutting draught door, but it may injure them by opening the fire door and letting cold air rush through the flues as is done in some cases.

Q.—How far will a jet draw water on a level at 60 lbs. steam pressure? The size of the jet is three-fourths steam, one inch suction and one inch delivery.

A.—There is hardly any limit to the distance that a jet will draw the water on a level. The jet will form a vacuum in the suction pipe and atmospheric pressure will drive the water through even if it were miles long. In this case the suction pipe would have to be without leaks. The length of the pipe will reduce the quantity of water delivered. In case of a very long suction, the pipe should be made larger than the jet calls for.

Q.—Will an injector force water into a boiler that has a higher pressure than another boiler to which the steam pipe on that injector is attached? Now, for instance, say the steam pipe of the injector is attached to one boiler and the delivery pipe is attached to another boiler. And if the pressure in the boiler to which the steam pipe is attached is lower than the pressure in the boiler to which the delivery pipe is

attached, will the injector force water into the boiler with high pressure?

A.—The fact that the injector overcomes the friction in the pipes and the turns in same (a heater, for instance) and lifts the check valves, will show that there is some power to spare. An injector will force water into another boiler with a higher pressure than the one from which it takes steam. The writer has noticed a difference of ten pounds on the delivery pipe from that of the steam pipe, and it is his impression that injectors can be built to do even better than that.

CHAPTER VI.

LUBRICATION.

Q.—Which is the best for a traction engine, a single or double connection lubricator; and how should they be connected, to the steam pipe or to the steam chest of the engine?

A.—A single connection lubricator is the most convenient to connect as there is but one connection to make; but it is generally believed that it is not as sure in its work as is a double connection, as, there being but one connection, the pressure is the same on the tube which supplies the water as it is on the discharge tube for the oil, there being nothing to force the oil into the steam but gravity. The water being heavier than the oil and there being a little more head to the water than to the oil, the oil is forced into the steam in this way. One can readily see that a little obstacle in the way will cause the lubricator to fail to supply the oil.

If a double connection lubricator is connected so that the connection for the water supply is taken from the steam pipe between the governor and the boiler, and the lubricator proper is connected to the pipe between the governor and the steam chest or directly to the steam chest, the lubricator will have an advantage, in that it has more pressure on the water supply

pipe than it has on the discharge end. Since the water supply pipe is a separate connection it can be built above the lubricator and thus get a greater head of water, and if the water or steam pipe of the lubricator should be connected to the same part of the steam pipe of the engine by having the water pipe built up considerably higher than the lubricator, the double connection lubricator will have the advantage over a single connection lubricator in that gravity can help more, due to the greater head of water, and thus overcome more of the troubles which are so common to the cylinder lubricator.

Q.—If feeding too much cylinder oil, as well as not enough, has a tendency to cut rings and cylinder, will water passing through the cylinder destroy the oil and cut the cylinder and rings? How much oil is required in running 10 hours, cylinder 8¼ x 11?

A.—Too much oil will never cut the piston rings. Dirty water caused by foaming of the boiler will cut the rings, but not clean water. One pint of oil should be abundant to run an 8¼ x 11 engine ten hours.

Q.—Having had a great deal of trouble with my cylinder lubricator, I bought an oil pump, and I found a great deal of trouble to keep the pump working. It is of the valveless type, but has a check valve on the pipe leading from the pump to the steam pipe of the engine. I noticed that the pump refused to start after it had been pumped dry, and if left stand without working, gets considerable water in the reservoir of the pump. The steam pipe is higher than the pump, but why does it get the water in the pump,

and why don't it pump the water back and then start to pump the oil?

A.—If the steam pipe of the engine is higher than the pump, it will not take long for the discharge pipe from the pump to condense steam enough to fill the pipe with water, and when the pump delivers oil through the delivery pipe to the steam pipe it does not need to displace the water with oil to get oil into the steam pipe, as the oil being lighter than the water, it will rise through the water in the same manner as does the oil in a sight feed lubricator. When the oil is all pumped out of the pump, it is not long before the water gets into the pump, especially if the valve leaks, and as some of these pumps refuse to pump water, the oil being lighter than the water, is forced out at the top of the body of the pump; in other words, the water fills up the body from the bottom. We see no reason why these pumps will not pump water as well as oil if the plunger is a good fit and the check valve is tight.

Q.—I have a compound engine which has a double oil pump, one part of which supplies the high pressure and the other part supplies the low pressure cylinders. Both plungers of the pump are driven with one shaft, there being two eccentrics on the shaft. Now, the trouble is, both pumps do not deliver the same amount of oil, yet they should have the same capacity, as the plungers are the same diameter and have the same stroke. The pump has no valves in it, but two valves on the delivery pipe leading to the high pressure cylinder and one in the pipe leading to

the low pressure cylinder. The plunger which delivers the oil to the high pressure cylinder gets the lesser amount of oil, and, in fact, to get a sufficient quantity to lubricate it properly, I have to run the pump so fast that the low pressure cylinder is flooded with oil, and in consequence there is a waste of oil. I have changed the connections and valves of the pump so that the plunger which delivered oil to the low pressure cylinder was connected to the high pressure cylinder, thinking this would help, but the trouble was about the same—the low pressure cylinder got much more oil than the high pressure cylinder.

Now, how can I get the pump to deliver the same amount of oil to each cylinder? If the pump is tight, should the difference in pressure of the cylinders make so much difference in the quantity of oil pumped? I would be grateful for any help you can give me in this matter.

A.—The plunger of your pump must leak. Leaky check valves would also cause this trouble, but as you changed the delivery pipes and also the check valves, the trouble seems to be in the plungers. Tight fitting plungers in the pump may help you, as the oil is solid enough to not be influenced so much by the difference in the pressure of the two cylinders. A better plan would be to have a separate pump for each cylinder. Then you could run each one the required speed to deliver the quantity of oil desired.

Q.—Will graphite stay mixed in lubricating oil so it can be used in a sight feed lubricator?

2.—We have a Zero lubricator and when it gets a little cold the oil stays in the upper part of the sight feed glass. Is there any remedy for it so it will go away?

A.—Graphite will not work successfully through the feed nozzle of a lubricator.

2.—A cold wind may chill the water in the glass so that the oil will become so stiff as to stop the flow through the feed nozzle. If the lubricator is connected between the throttle and the cylinder the piston will pump the oil through the feed nozzle when the throttle is shut off and the engine is still running due to the power stored in the flywheel. The proper place for a lubricator is between the throttle and the dome on the boiler.

Q.—I wish to ask you what harm cylinder oil which the lubricator feeds while the engine is not running will do?

A.—Cylinder oil fed into the steam pipe or steam chest can do no harm to the engine. It is simply a waste of oil.

Q.—Would you advise the use of graphite in the engine cylinder? If so, in what quantity?

A.—Graphite is very good for cylinder lubrication, as it mixes well with cylinder oil. One part of graphite to six parts of oil may work through some lubricators.

Q.—Why is it that the oil will run up beside the glass in lubricators at times; also how to operate a Detroit lubricator successfully?

A.—The glass may fill with oil from different

reasons. A very common one is because some dirt or sediment forms around the top of the nozzle at the bottom of the sight feed glass. This causes too large a drop to form and in raising it is liable to strike against the side of the glass and break. In such cases the glass should be removed and the nozzle made clean and smooth. An imperfect gasket will also cause the glass to fill with oil on account of the leak-

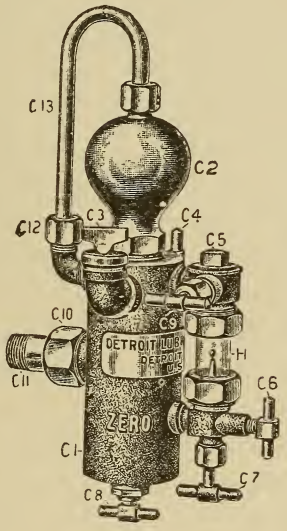


Fig. 1.

age of the water, or by clogging the opening at the top of the sight feed glass. In such cases the opening of the valve in the support arm of the Improved Standard, *A9,* or the valve, *C9,* in the Zero lubricator, Fig. 1, should be graded to suit the engine. With some engines this valve may be left wide open, while with others it must be closed almost

entirely. In case of such troubles it is also well to empty the lubricator and blow steam through the different valves so as to thoroughly clean out all the passages.

Q.—Desiring to place my lubricator on rear of boiler and cylinder being on front end of boiler, would like to ask through The Review if the long feed pipe which will be necesary to convey oil to cylinder will have to be on an incline from oiler to cylinder, or can it be horizontal? Would it make any difference in the working of the lubricator?

A.—The long feed pipe should be higher at the lubricator end so as to allow the steam to get into the lubricator and the oil to flow down out of the pipe. It should have enough drop toward cylinder end to make up for the amount the engine is out of level by being on an incline at times.

Q.—How can one of the small cup lubricators be made to flow regularly? I can fill this and turn it on full opening and find in the course of an hour that it has not gone out of the cup at all while engine is running, but as soon as shut off it will all run out. Can you explain to me a way in which my trouble can be overcome, if it can be?

A.—The cup in question is a plain oil cup with nothing but a filling plug and a valve to shut off the pressure while filling, and same to leave oil flow down. There are cups of this kind made with a little equalizing tube to allow the pressure to get on top of the oil. This makes the oil balanced and it can then run down. But without this tube the pressure holds the

oil up in the cup and as soon as the steam is shut off the engine pumps a vacuum in the steam pipe or steam chest of the engine, and thus the oil is drawn out of the cup.

Q.—If the cylinders happen to run short of oil (not enough to make them squeak) the eccentrics will pound very hard; they are not loose. I would like to know the cause of this.

A.—The absence of oil under an unbalanced valve has a tendency to make it run hard. The valve will suffer for a want of oil long before the piston. The oil should be fed continuously. If it were not for the warning "pound" of the eccentric many a valve would be ruined for the lack of oil.

Q.—My engine makes a squeaking noise; it is either in the cylinder or in the guides. I can't tell which. The front of the upper guide is a little rough. The engine has been run two seasons. The man in charge of it the first season said the sight lubricator wouldn't work. There was plenty of oil went through the cylinder, but depended on the oilers on the steam chest. He would fill it and in about fifteen minutes it would be gone, and the engine would then run about half an hour without oil.

A.—The best way to lubricate a cylinder is to have the oil fed by drops continuously. If the engine continues to squeak after being oiled, this would indicate that the cylinder is out of line with the guides or that the crosshead is not properly adjusted; causing the piston rod to be forced out of center. Sometimes a squeak comes from the valve or valve rod.

Q.—Is one lubricator sufficient for a double engine?

A.—One lubricator is sufficient to oil a simple double engine, providing the supply steam pipe enters the branch pipe in the middle. If the main or supply pipe enters the branch pipe closer to one cylinder than the other, the cylinder that is nearest to main supply pipe will get more oil than the one farther away. The feeding capacity of one lubricator to oil two cylinders of the traction type is ample.

Q.—I have noticed at times the oil in a lubricator will turn brown when going up through the sight feed glass, which gives trouble, fogging the glass.

A.—It may be your oil is not of a good quality. It often happens, when the sight glass is not full of water, that the oil adheres to the glass. This can be blown out without taking the oil out of the lubricator. The glass should have time to fill up full of water before the feed is started.

Q.—What is the cause of the sight feed glass breaking on the Swift lubricator?

A.—The cause of the Swift lubricator glass breaking is being screwed up too tightly. A wrench should never be used to screw it. You can get enough pressure on the gasket by using your fingers to screw it up.

Q.—Which is the best for a wrist pin, hard or soft oil?

A.—Hard oil is used very successfully for wrist pins. Automatic compression cups should be used.

Q.—I am using a force feed lubricator and use

one-half gallon of oil in ten hours. The oil enters the lead pipe just above the steam chest, and oil runs through the steam chest and cylinder, and then through the heater and on the ground. It seems to do no good and the cylinder will run dry anyway, and in hard pulling I have to use the hand pump to put in more oil. Now I would like to know what the trouble is with my cylinder.

A.—Your oil is likely of a poor grade. Try something better and see if you find relief. A less quantity of a better grade of oil will do more good.

Q.—I have an 18 h. p. compound Advance engine, and would like to know how would be the best way of connecting my lubricators so I could get them back at the foot-board to operate them; whether the pipes should slant up or down, and if I should use double or single connections; or, if single connections, lubricator would work like a Swift.

A.—To have a lubricator far from the cylinder where a long delivery pipe has to be used, it should incline or drain toward the cylinder so that water may not lie in it and thus freeze. As far as getting the oil to pass through the pipe, it would not make any difference, for if the pipe inclined upward to the cylinder and was full of water, the oil would find its way through the water.

The lubricator should be of the double connection type, and the upper pipe which supplies the water should drain toward lubricator, with a valve next to the steam pipe, so that it can be emptied in case of freezing. The upper pipe should be connected be-

tween the throttle and the boiler, so that the lubricator may be started to work before the steam is turned into the cylinder. A single connection lubricator will not work well with a long delivery pipe. A Swift will be all right.

CHAPTER VII.

FIRING.

Q.—Which is the most economical way to fire a traction; to keep a thin fire over the whole surface of the grate, or fire first on one side and then the other?

A.—The best and most economical way to fire is to have a thin fire over the entire grate surface.

Q.—How would you bank the fire in an open bottom boiler?

A.—If the ash pan is not tight enough to prevent the fire from burning too rapidly, the smoke box door may be left open. The most common way of banking fire is to get the fire on a pile in one end of the fire-box, covering it well with coal and leaving part of the grate bare. Ashes are sometimes used to cover the fire. Every make of engine takes different treatment; a little experimenting will soon bring you to the right plan.

Q.—I have a great deal of trouble with clinkers in the grates, no mattter how it is fired.

2.—Would rocking grates do any better, and what would they cost?

A.—Your trouble from clinkers may come from carrying too thick a fire. In starting, spread the fire over the grates, and it should never be more than

four inches thick; break the coal so that the largest pieces are not more than about three inches in size. Throw the coal over the fire in thin layers, never throw a shovel full at one place, but always spread it at the thinnest place, keeping the grates covered; never stir the fire from the top, for if you stir it while it is burning brightly it will at once make clinkers. If it is necessary to get the ashes off the grates it should be done by shaking the grates or poking them out from below. The very important point is to carry a thin, clean fire.

2.—Rocking grates are very convenient and would no doubt help you to keep a clean fire. A set with all attachments would cost about 25.00.

Q.—Knowing that the exhaust nozzle increases the back pressure and that back pressure reduces the power of an engine, how would it work to let the exhaust go free and produce an artificial draught by means of a fan or steam jet? Would the difference in the power make up for the energy taken to produce the draught without the exhaust steam?

A.—No. It takes very little back pressure to produce enough draught to make a fire burn in a traction boiler. In some engines the most of the back pressure is caused by a poor distribution of the steam, and if the exhaust nozzle were taken off there would be little difference in the back pressure. We expect to find some back pressure in every engine, and since the exhaust, even if it is let go free, without a nozzle, has a certain velocity and this we get without costing any-

thing, and it takes very little reduction in the nozzle to increase velocity of the steam to make sufficient draught. To create the draught by means of a jet, the whole amount would have to be done with live steam, and it would take more extra energy than to sharpen up the exhaust with a little back pressure. If, however, the exhaust could be used to get more power by means of a condenser as in stationary practice, there would be more than enough energy gained to either run a fan or steam jet.

Q.—Please explain to me how to fire a straw burning firebox boiler, and why the flues get to leaking so easily when straw is used for fuel?

A.—There is nothing which will worry a man so much as trying to fire a boiler with straw, when he does not understand the art, but a free steamer in the hands of an expert fireman is an easy job. One can make a great deal of extra work for himself by stirring the fire too much, thus making an extra amount of clinkers on the grates and stopping up the tubes at the tube sheet. A poor fireman who keeps lifting the fire and stirring it with the firing fork will have to clean off the tube sheet as often as six times an hour; while a good fireman will not clean the tube sheet any oftener than once in two or three hours.

One of the important points (as in firing with wood or coal), is to keep the grates well covered, that is, not leave any dead space for cold air to rush into the firebox. If the firebox is wide, one can be sure that the grate is always covered by placing a fork full on one side, the next one on the other side

and then one in the middle, and if this is kept up there is no danger of leaving any bare places on the grates. Too many firemen push all the straw to the center and poor results are sure to follow.

We have warned you against stirring the fire; yet there is some stirring needed. After the grates are well covered with ashes or clinkers (which will be noticed by the feel of the fork while the straw is being pushed in, mainly on account of the straw not burning so freely), the fork can be put under the fire with the points of the tines turned downward, and the ashes or clinkers can be pushed through the grates without disturbing the fire very much. This will allow the air to get to the fire again and make it burn freely, which will be noticed when the next straw is placed in the firebox.

The draught door, or ash pan door is made large enough to pull the ashes out, which should be done from time to time, but the ash or draught door should not be kept wide open. An inch opening is generally sufficient to admit enough air for easy steaming, and whenever firing is stopped the draught door should be shut down. At first glance this may seem to be of little account, but straw for fuel makes a very uneven heat. While the average heat is sufficient to keep up the steam, yet at times the heat is much greater than when burning wood or coal. Thus the flue sheet and flues are heated to a very high temperature at times, and if, while the engine is yet running, the exhaust is allowed to draw much cold air through the firebox and into the tubes, we can then see where the

trouble comes from. There is nothing which will make the tubes leak so quickly as getting them real hot and then allowing cold air to strike them while in a heated condition. The beads of the tubes are exposed, and being so much thinner than the tube sheet, they will contract sooner than the tube sheet and thus become loosened. After this occurs a number of times the tubes will become so loose that they will rattle in the tube sheet when the boiler cools down.

An imperfect fire chute door will also cause this trouble. It sometimes happens that the door in the chute will stick, and while firing does no harm, especially when the chute is kept full of straw, but when firing is stopped, the straw will burn out of the chute and the door refusing to drop, cold air will rush in and the tubes will be sure to be damaged.

In burning straw the ash door should be kept closed as far as possible, only allowing it to open far enough to burn the straw. And it is surprising to see how little a space is sufficient to admit the required amout of air.

Q.—Is there any advantage for a straw stoker for a traction engine other than a labor saver?

A.—With a good straw stoker much of the trouble of leaky flues will be avoided; as in firing by hand, at times too hot a fire is made, and often the fire is allowed to die down suddenly. With the stoker a more steady fire can be had and there should not be any more tendency to leaky tubes than with coal for fuel. The accumulating of ashes on the tube sheet

will also be reduced as there will not be so much stirring of the fire and thus reduce the tendency of the straw to fly through the fire.

Q.—I have a cone screen in my stack and when I use it, it retards the draught so that the boiler steams very hard. Can there be anything done to help the steaming quality of the boiler when using the screen?

A.—The draught can be increased by reducing the exhaust nozzle. Another way to help the draught while using the screen is to invert it. Instead of having it to extend downward in the stack, turn it upward. Thus the smoke will have an easier outlet and you will find the draught much stronger, and good results may be had in this way without reducing the exhaust nozzle.

If the frame on which the screen is fastened will not permit of being reversed, the screen can be taken off and fastened on the top side of frame.

Q.—I have a 13 h. p. engine. It does good work, but it fires awfully hard. It seems to have plenty of power, but we can't hold the fog. The draft is such as to fan the blaze down in the ash pan and back against the fire doors.

A.—Your trouble seems a lack of steaming capacity. If you have power enough, carrying a higher pressure will not help you. On the other hand you may cause an accident with your boiler. Your best plan is to either get your engine to use less steam or make more steam for the engine. To have your engine to use less steam see that the valve and piston are in good order so as not to leak steam. If you find

they are all right, you can increase the draught by reducing the opening in the exhaust nozzle, thereby burning more fuel and making more heat, thereby making more steam. Be sure that the exhaust nozzle points directly up the stack, if it does not the draught will not be so good. The steaming quality of an old boiler is not as good as a new one, on account of the scale which is so common to boilers and which interferes somewhat with the heating surface. For this reason it is sometimes necessary to make an adjustment of this kind.

Q.—Could a handy man make a coal slack burner, using a fan to blow the dust into furnace and burning it in suspension? Could straw be burned this way?

A.—When coal dust is burned as fuel it is blown into the firebox by compressed air. A fan is not able to generate enough pressure for the purpose. If straw could be pulverized may be it could be used in the same way.

Q.—Will using the steam blower on a boiler to make the fire burn, make the flues leak any quicker than the exhaust from the engine?

A.—The flues will not be affected by the use of live steam instead of exhaust steam to create a draught, if they are both directed up the stack.

Q.—Could you burn coal in a straw burner boiler? If not, why not?

A.—Coal for fuel can be used in a straw burner by using coal grates, which are usually provided by

the builder of the engine. In some cases there is a fire brick arch used for burning straw. This will assist in burning coal. However, the arch may be removed if desired. The exhaust nozzle may be enlarged for burning coal, as it does not require as strong a draught as for straw.

Q.—I have a Russell 16 h. p. compound engine. Sometimes when the engine works hard for some time, using coal, a fire starts in the smoke box and it seems to take the draft of the main fire so that it is impossible to keep up steam. The fire will stay there and the smoke box will get red hot, as also will the smoke stack, and by and by the flames will burn out of the stack, if I do not stop.

I was thinking it was the waste cylinder oil and the gas of the coal and dirt and soot that gets in the smoke box. I clean my flues twice a day, also the smoke box, but the fire would start any way.

A.—Your trouble is no doubt caused by having your grates stopped up. It may be you have your fire too thick. The trouble is, after the grates get stopped up, the air cannot get through the fire to support the combustion and the gases go through the tubes of the boiler unburned; and after they get into the smoke box they ignite, thus making more heat in the smoke box than in the firebox and tubes. A fire should not be over five inches thick; with such a fire you will not have trouble of this kind.

Q.—When an engine is employed for threshing and straw is used for fuel and fireman is employed, who should then have the blame for accidental fires

—the fireman or the engineer?

A.—The engineer should be responsible for the engine. He should see that the fireman is careful about his firing and not allow an accumulation of straw about his engine. He should see that care is taken when pulling out ashes. A supply of water should always be on hand. The engineer of a straw burner has very little to do and he should be on the lookout in case of fire from sparks and should assist the fireman generally; as the fireman has the heavy end to hold in this case.

CHAPTER VIII.

GOVERNOR.

Q.—The governor on my engine does not control it satisfactorily. I have to set speeder spring very tight to get proper speed for threshing. When separator is empty it runs too fast. A new valve did not better it. It is a Pickering. Would it do to raise the valve a little, so as not to have the spring so tight?

A.—If you raise the valve it may not shut the steam off when the engine is running light. The governor should cut off the steam when the balls are spread. To adjust the valve correctly you can take the governor belt off and without any belt on the flywheel, have some one turn on full steam while you pull the governor balls out by hand. You can readily tell where the valve is in relation to the seat by this method. If the engine runs at high speed when the balls are pulled out to the extreme, this would indicate that the valve is too high; if the engine is shut down before the balls are pulled out to the extreme, this would indicate that the valve is set too low. Adjust the stem so that the valve comes to the seat when balls are out. To tell when you have this adjustment, you will find that the engine stops just as the balls strike the outward position, or to make the engine run steadily, while running without

a load the valve should admit enough steam (when under full steam from the throttle and when the balls are pulled out) to run the engine very slowly. In other words, the valve should be slightly off the seat when the balls are pulled out to the extreme. After this is done and if you do not have the proper speed by giving the speed spring a reasonable amount of tension, the diameter of the pulleys should be changed. If you want to run the engine faster, the pulley on the governor should be increased in diameter. If you want to run slower the pulley on the crank shaft should be increased. As it is likely not to take much, one or two thicknesses of belting put around the pulley will likely be sufficient. The pulley may be wrapped with other things to increase the diameter.

Q.—What is the matter with my governor? It is a Waters, 1½ inch. I cannot make it run the engine slow enough when doing light work, such as sawing wood. The stem seems to be long enough, as I can screw the valve down to bottom of seat. Should the valve have a solid bottom or an open one? This valve is open at the bottom. It will let the engine run from three to four hundred revolutions per minute. It will hold the engine when doing heavy work, but does not govern it well.

A.—The plan of changing the speed with a Waters governor is the changing the valve. When a slow speed is required the valve is screwed down into the seat, thereby cutting off the steam with but little movement of the balls and springs. The valve opens but little in this case and there is not much power in

the engine. When the governor valve is set to run the engine faster the valve is set to open farther, thus having to move the balls and spring farther. To get better results at a low speed the better plan is to put a smaller pulley on the governor; the valve can then be set to open farther.

Q.—I have an engine with a Waters governor, and in sawing it controls the steam O. K. when I let the stem up. But when I shut the stem down the engine runs just as fast if not faster. Please tell me the trouble.

A.—The valve of the governor may be worn very much; perhaps it is broken; and it may be when you screw the stem down you get it so far that it reopens at another point. Your best plan will be to take the valve out and examine it, and try it into the seat to see if it fits properly.

Q.—What causes the governor to admit so much steam at times that the engine nearly runs away and then shuts down so it almost stops and starts off again? Packing is in good shape and I find nothing the matter with governor. This is on a link motion engine.

A.—Sometimes the packing is all right, but the stem is worn so that it has shoulders. In this case the shoulders will wedge into the packing and thus make the stem stick and cause the governor to "race." It sometimes happens that the valve will stick in the seat. A loose seat or a bent stem will also cause this trouble. A tight or dry joint will also cause racing.

It sometimes happens that an imperfect belt will cause trouble of this kind.

Q.—I would like to know why the governor on a compound engine don't control engine as perfectly as on a simple. I am using a Pickering governor.

A.—A compound engine is not so quick to respond to a load as is a simple engine; as the steam is admitted to the high pressure or small cylinder and the low pressure or large cylinder does not receive the steam till after it gets through the high pressure cylinder, and the full power of the engine is only realized after both cylinders are at work. However, the economy of a compound engine should more than make up for this, and if the engine is large enough for the work, the variation in speed should be so slight that it will hardly be noticed.

Q.—Where will the governor of an engine do its work best, next to the boiler or next to the engine?

A.—The action of the governor on the engine will be felt quicker when the governor is close to the cylinder. If the governor is too far from the cylinder the regulation is apt to be sluggish. The proper place for the governor is close to the cylinder.

Q.—Will a governor on an engine when put in a horizontal position run as regular as one that is upright? When the balls go up they will go slower, and faster when they go down on other side, and will be closer to top of shaft than bottom.

A.—This depends upon the construction of the governor. Most spring governors will run as well in a horizontal as a vertical position.

Q.—I have an Eclipse governor and cannot get the speed I need. I understood there was quite a range of speed in this governor. The horizontal spring is not arranged for conveniently changing the tension. I have taken the top off and cannot see how it can be done there. I have been used to the Pickering and Waters governors, but I cannot see how this one can be changed as either of these are. I wish you would help me out, if you can.

2.—The governor runs unsteady part of the time, that is, it runs above its speed and then shuts off the steam and slows down below its speed and keeps this up for quite a while. I have repacked the stem and don't think the trouble is there. Can you also help me out in this point?

A.—The horizontal spring is for keeping the stem up in place and not for the purpose of changing the speed. You will notice the stem is made in two pieces and the two pieces are connected by small castings just above the stuffing box. There is a screw in one of the levers which works against the other lever, and by means of this screw the stem can be made longer or shorter. This changes the action on the large spring and varies the speed. The range of speed on this governor is about 200 revolutions per minute.

2.—Take the valve out of the governor and see if it shows signs of sticking. If there are any spots on the wings of the valve they can be dressed off carefully with a fine file and perhaps the disc of the valve may be a little tight and can be dressed off at the spots which indicate its being tight.

CHAPTER IX.

BEARINGS.

Q.—Is babbitt instead of brass a good thing for a connecting rod?

A.—Babbitt is a good thing for the crank pin, but not for the crosshead pin. The fact that it does not wear so well in the cross head end, may be due to the fact that nearly all cross head pins are smaller than crank pins. Babbitt does not heat as easily as brass and has equally as good and in many cases better wearing qualities. When it is neglected by lack of oil, or if adjusted too closely, it does not scar the pin as does brass. Men who have had experience with both babbitt and brass testify to the superior qualities of babbitt in the crank pin box of the connecting rod.

Q.—What is the simplest and most economical way of rebabbitting main shaft on engine?

A.—After taking out the shaft, the old babbitt metal is removed and all the anchor holes for fastening the metal are cleaned out. The shaft is then replaced with sufficient blocking under it to allow the proper thickness of metal under it. It can be wedged up to its position by small iron wedges which can be taken out after pouring, or by a small block of babbitt metal which can be left in the box; or sometimes

the shaft can be held up by the crank disc and fly-wheel or gearing. The shaft should then be brought square with the cylinder and if the crosshead guides are of the bored type the only thing to watch beside getting it square with the cylinder is to get the pinion to gear properly into the spur gear. However, to allow a reasonable amount of metal under the shaft will not be far from right for the gearing. The shaft may be made square with the cylinder by means of a fine line or thread, stretched through the cylinder; and when the line is true with the cylinder it should come to the center of the crank pin. That is, if the crank pin box is three inches wide the line should be one and one-half inches from the crank. The fastening for the line should be beyond the crank, so that the pin can be turned from one end to the other, coming just down to the line at each end. This can be done by having the shaft fixed so that it cannot roll out of its place, and the distance from the line to the crank should measure the same at each end. This will make it square with the cylinder. Clay or putty is used to prepare the box for pouring. The old metal can be used by adding new to it. Care should be taken so as not to get the metal too hot. It is better not to heat the metal to a red heat. After the metal is poured into the boxes the shaft is taken out to scrape the boxes. This is necessary on account of the shrinkage of the metal. A little lamp-black or red lead mixed with oil is good to rub on the shaft to mark the places where scraping is necessary, which is done by turning the shaft in the boxes. Filing it out

with a half-round file will also do, but a scraper made by grinding the edge of a half-round file is the most convenient tool to use for this purpose. This scraping or filing will have to be repeated a number of times to get a good bearing. The caps may then be poured, placing the proper liners between the caps and boxes. The babbitt in the cap is fitted to the shaft in the same manner. Oil grooves are chipped in the box or cap, or in both in some cases. In the case of locomotive or flat guides the shaft should be level with the crosshead pin. In some cases it may be necessary to reset the guides to get the shaft level with the crosshead pin and at the same time have the gearing in the proper shape.

Q.—How would you babbitt the crosshead shoes to raise them in line with the line through the cylinder?

A.—To babbitt the crosshead shoes, first see that the guides are in line with the cylinder, then block the crosshead up so that the piston rod is in line with the guides. This can be done by placing the crosshead to the far end of the guides, then by measuring from the lower guide to the rod at both ends you can get it in line. Do not try to get the rod centered with the top and bottom guides, but simply in line with either the top or the bottom. The metal can be then run in, and after dressing it off proceed to test it by watching the running of the piston rod at the stuffing box. If the rod runs through the stuffing box without any vertical or cross motion, the guides are in their prop-

er place. If the rod moves in an upward direction at the stuffing box as the crosshead approaches the stuffing box, this will indicate that the guides are too high; but if the rod moves in a downward direction while the crosshead approaches the box, this indicates that the guides are too low. The same rule will apply to any side motion which the rod might have. A close observer can readily determine which way to move the guides by the motion of the rod.

Q.—When brass boxing have been badly cut by excessive heating of the crank, could it not be remedied by boring them out and running them full with a thin layer of babbitt, so as to leave the pin as it was?

A.—Lining of brass connecting rod and crank pin boxes with babbitt metal is a very good practice. You will find that babbitt will wear longer and run with less heating than a solid brass box. Babbitt does not work as well as brass in the crosshead end of the rod.

Q.—My engine when pulling a reasonable load runs smooth and all right; but when pulling a heavy load it pounds and knocks. What do you think is the matter?

A.—The knocking or pounding of engine when working under a heavy load may be due to the fact that there is considerable play or looseness in the main crank shaft bearing. This bearing should be kept adjusted as closely as possible without causing it to heat. The main box cap should rest firmly upon the liners or shims and the nuts screwed up firmly so there will be no play or movement of the cap. The

wrist pin brasses should also be keyed up as closely as possible and great care should be taken to adjust these boxes gradually so that they will not heat. The crosshead pin brasses should be adjusted as close as possible.

The best way to adjust this box is to remove the strap and wrist pin brasses and then adjust the boxes. Try to move the rod vertically. By doing this there will be no danger of getting it too tight.

If the engine still knocks after these parts have been looked after it might be possible that the piston head is loose on the piston rod. To find out if this is the case it is necessary to remove same from the cylinder and by tapping the head with a hammer you will notice at the riveted end of the piston whether it shows any looseness. If the piston is loose in the head it ought to be sent to the factory for refitting. This, however, can be done in the field.

We would recommend making a small wood fire placing the head with the rod up on the coals so that the head will become heated. It does not require very much heat for it to expand. The piston should then be driven in as firmly as possible and allowed to cool, and the riveted end should be riveted more firmly.

It occasionally happens that the piston is loose in the crosshead. To fasten this tighten up on the clamping bolt, which will set the crosshead tightly upon the piston rod, and screw up the jam nut tightly against the crosshead.

Q.—What do you think of wrapping thin paper

around the shaft and pouring the whole box at once? That is, of a split box.

A.—Wrapping paper around the shaft to compensate for the shrinkage of the babbitt metal is a good idea. Otherwise the metal has to be dressed out to insure free working of the shaft.

Q.—Will you tell me how to babbitt the crank pin brasses?

A.—You can fasten the babbitt in a crank pin box by drilling the inside full of small holes about one-fourth of an inch in diameter; or another way is to heat box and tin the inside with a soldering copper. Put the box into its place, square the rod by the crank disc, have the key out as far as it will go to allow for as much babbitt as possible. Make two strips of wood to put between the boxes to keep the babbitt from running together. The top strip should be short enough to allow for a gate to pour the metal; about the thickness of the outside flange of the box is enough to admit the metal so the upper stick can be that much shorter. The upper stick also serves to hold the box and rod up to its place. The top stick should be a little the thicker so as to leave a little more space on the top side of the pin to allow a free course for the metal to run. The box should be put in hot so that the solder can unite with the babbitt. This makes a very solid job. The babbitt will wear down to the brass without coming off. When holes are drilled in the box instead of tinning the surface, the box does not have to be heated. The babbitt should be scraped to fit the crank pin, due to the

shrinkage of the metal. A babbitted box will wear longer on a crank pin than a solid brass one.

Q.—How can I fix the crosshead on my engine? The upper shoe is worn and cannot be adjusted. The lower shoe can be adjusted by a screw. When I screw it up tight it throws the piston rod too hard on the gland of the stuffing box and makes the piston rod heat. The engine pounds worse when under the belt or turning under. Can it be remedied without taking off the crosshead?

A.—The piston rod should be parallel with the guides of the engine. If the piston rod needs to come down to make it so, you should put a liner between the crosshead and top shoe. By taking back the lower shoe as far as possible, you can get the crosshead down enough to drive the upper shoe off far enough to put the liner in, as the top shoe is simply fit on a hub or stud.

Q.—What makes the crosshead in an engine run out of true? Top shoe runs outside of slide and bottom runs inside of shoe.

A.—We understand from your question that the top shoe of the crosshead extends out over the guide and the bottom shoe extends in. If this is the case there can no trouble come from this cause. The important thing to note is that the crosshead is the correct height. This can be found by watching the piston rod while the engine is running. If the stuffing box works up and down the crosshead is either too high or too low, and when the crosshead is properly adjusted, the rod will run true.

Q.—How is the pressure on bearings figured? It is spoken of as so many pounds per square inch. How much of the circumference of journal is taken?

A.—The pressure on a bearing is computed by multiplying the diameter by the length of the bearing. Thus a bearing two inches in diameter and four inches long has $2\times4=8$ square inches of bearing. The circular shape of one-half of the shaft is equivalent to the same thing as if the shaft were cut through its diameter, and the thrust would come against the flat side of the cut.

Q.—Will you kindly explain in a comprehensive manner the correct method of lining up crossheads, or guides, which have crosshead pin cast in one piece, thus not permitting the use of a string through the crosshead and cylinder to line by? Such crossheads are being used by the Nichols & Shepard and the Frick companies. Please also explain method used by engine builders for lining, and also please give diagram, if convenient.

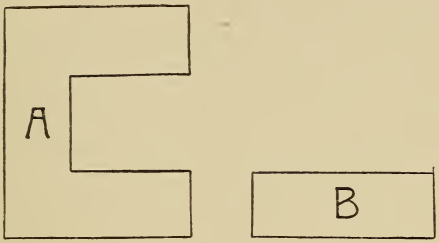
A.—The difference between lining up the crosshead on a bar guide and a Corliss guide engine is: on the former you line up the guide bars to the crosshead and on the latter you line up the crosshead to the guides.

On a bar guide engine, if crosshead is worn, it should be filed so the bearing surface is straight on the bottom, top and sides and in line with the piston rod.

If the guide bars are worn they should be planed

off or the bars can be turned upside down. They should have a straight, level surface for the crosshead to run on.

Cut out packing from thick paper, shipping tag is best, thus:



Place enough of these under upper guide bars to hold the bars up off the crosshead. Then loosen the bolts so lower guide bars will be down below the crosshead.

Adjust the piston so you can move it back and forth by hand. Take off connecting rod and rear cylinder head and remove stuffing box gland and packing. Move the piston and crosshead to one end of stroke and slip the gland in stuffing box. Draw up bolts on guide bars so the guide bars just touch the bottom of crosshead. Then move the crosshead to opposite end of guide, slip the gland in stuffing box and draw up this end of bars so they just touch the bottom of crosshead.

If the guide bars are worn so the ends will not allow them to raise high enough, file down the ends of the bars.

In using the packing, take enough of the packing,

"A," so that when pinched together, it will be just thick enough to crowd one corner of the packing in between the lower guide bar, yoke and cylinder head lugs. Then loosen the bolts, put the packing in place and tighten the bolts again. Do this at all the four ends of lower guide bars.

Take a spirit level or straight edge and place it across the top of the two lower guide bars and see that the full width of the bars are in line with each other and level with heater. If not level, place packing, "B", under the outer or inner edge of bar to level it up. Rub chalk over the bottom of the guide bars, hold the gland in stuffing box and move the crosshead the full length of stroke and see that it rubs the chalk even at both ends of the guide bars, lengthwise and crosswise. If it does not, take out or put in packing until it does. Adjust the upper guide bars in the same manner.

After the four guide bars are adjusted up and down to a true, even bearing and run free on crosshead, place the connecting rod in position and tighten its boxes, put gland in stuffing box and loosen the bolts to guide bars just a little, drive the guide bars in or out until they just touch the edge of the crosshead. Then tighten the bolts, chalk the inside edge of guide bars and have some one turn the flywheel slow and watch and see that the crosshead does not bind at either end of bars and has an even bearing on the bottom, top, and edges and runs free.

A careful man can adjust the guide bars to crosshead in this manner better than with a center line.

CHAPTER X.

MISCELLANEOUS.

Q.—When engine is being laid up for the winter is it best to take off cylinder head and steam chest cover and oil cylinder and valve seat, or can you oil them well enough by turning on lubricator heavily and running engine with cylinder cocks open for a few minutes?

A.—A good plan to oil the cylinder and valve is to run the engine slowly and turn the lubricator on as fast as it will run; keep this up about the last five minutes you run the engine.

Then drain the cylinder and steam chest thoroughly, and there is no harm which will come to it. If, however, the engine must stand idle for a great length of time, the cylinder head and steam chest cover can be taken off and cylinder oil applied to the cylinder and valve face. Cover the exposed surface of the cylinder and valve face with oil, then turn the engine by hand until the oil is carried under the piston and valve so the whole surface of the cylinder and valve seat may be covered. Then replace the cylinder head and steam chest cover, and it will keep from rust a long time.

A.—In a front traction wheel where the spokes are bent and seem to be too long, how can they be

straightened or gotten taut so that they will work under tension.

A.—Heat the spokes red hot. They can then be straightened and when they cool off they will be taut by the contraction of the metal.

Q.—The flywheel has come loose a number of times and has worn itself so that the shaft is too small for the hole in the wheel. How should I repair it?

A.—If you cannot hold the flywheel tight by driving the key, you can cut another key way one-third of the distance around the shaft and drive a key at that place; then with the other key and the bearing against the shaft on the opposite side which the two keys will make, thus making three points of contact, the wheel can then be securely held.

Q.—How would you treat a boiler after rig is put in shed? Is it good to pour oil in boiler before letting water out? If so, what kind would you recommend?

A.—The inside of a boiler takes care of itself, as there is usually a coating of lime on the surface which keeps it from rusting. An important thing to do is to see that all mud is cleaned out of the bottom, for in freezing weather the mud will expand and injure the boiler.

Q.—Which is the best, hard or soft babbitt for the wrist box on the engine?

A.—Genuine babbitt which is soft is believed to be the best all around babbitt. It being rich with tin and therefore soft. Copper hardened genuine babbitt will stand a greater pressure, but does not have

the anti friction qualities. Metals rich with lead are good anti friction metals, but wear faster and do not stand as much pressure. It cannot be decided, which is best, whether hard or soft metals, as both kinds are sometimes bad and good. Your best plan is to get a good grade of babbitt, if you cannot get genuine babbitt metal.

Q.—What do you think are the best pulling engines made, the ones with driving wheels set entirely behind the boiler, or in the middle of the firebox? I think the one best with the axle bolted in the middle of the firebox. I think you want the drivers where they can have weight enough to hold them to the ground, and not so they will fly around like the flywheel. Am I not right?

A.—Sometimes an engine with the axle in the middle of the firebox is the best puller and at other times the engine with the axle at the rear end of the boiler is the best puller. It all depends on the condition of the road, the length of the boiler, and where the engine and tanks are mounted on the boiler. A short boiler with the axle in the center of the firebox will usually raise up in front when pulling a very heavy load, and a long boiler with the axle at the rear end of the boiler will slip its drivers when pulling a very heavy load. This is the tendency of these two types of engines, but there are some of both classes which do very well, and it would be difficult to say which one is best.

Q.—Please tell me what to use or how to make a good dope for screw joints of pipe?

A.—A good lubricant or "dope" for the screwed joints of pipe, says Steam Engineering, is made by taking one part of white lead, one part black lead or powdered graphite and four or five parts of machine oil to mix it to a fluid consistency. To a pint of the mixture, add about one teaspoonful of flour emery and thoroughly mix. When using the "dope" on a joint, put a small quantity inside of the fitting and an equal amount on the thread to be screwed in. After the pipe is screwed nearly home, back it out for about one turn and then screw in snugly. The result is a perfectly tight joint, if proper care has been taken in cutting the thread and even without this care the mixture goes a long way towards making perfect work. The flour emery polishes the parts; especially when the pipe is turned backward, and tends to make practically a ground joint on the surface of the thread.

Q.—What is the mean effective pressure to the boiler pressure? Say we have 100 lbs. boiler pressure, what would the mean effective pressure be?

A.—In an automatic cut-off engine the initial pressure would be near to the boiler pressure. By initial pressure we mean the pressure in the cylinder at the beginning of the stroke. At the initial pressure that 100 lbs. boiler pressure would naturally make the mean effective pressure would be about 50 lbs. at a cut-off of one-fourth of the stroke and about 77 lbs. at one-half cut-off.

In throttling engines such as traction engines with a boiler pressure of 100 lbs. the initial pressure would

probably be an average of 85 lbs. which would give a mean effective pressure of about 44 lbs. at a cut-off of one-fourth of the stroke and 68 lbs. at one-half cut-off.

Q.—How are malleable castings made?

A.—The castings are first made of ordinary cast iron, or charcoal iron in the usual way; they are then packed in cast iron boxes with oxide of iron and exposed to a full red heat for from three days to two weeks, according to their size.

Q.—What is the melting temperature of tin, of lead and of antimony?

2.—What is the proper metal or alloy for filling fusible safety plugs?

A.—Tin melts at 442 to 446°, lead at 608 to 618° and antimony at 810 to 1,150°.

2.—Tin is used for fusible plugs in boilers.

Q.—What kind of acid and how do you mix it to make solder stick to tin?

2.—Is the same acid used to make babbitt stick to brass or cast iron?

3.—Can babbitt be too hot to make a good box?

A.—Soldering fluid. Take 2 oz. muriatic acid, add zinc till bubbles cease to rise, add one-half teaspoonful of sal ammoniac and 2 oz. of water.

2.—The foregoing will do well to tin brass or iron.

3.—Babbitt is often ruined by overheating it. It should not be any hotter than to just scorch a pine stick.

Q.—What is the value of wood for fuel as com-

pared with coal, or how much wood does it take to equal a ton of coal?

A.—One cord air dried hickory or hard maple weighs about 4,500 lbs. and is equal to about 2,000 lbs. coal.

One cord air dried white oak weighs about 3,850 lbs. and is equal to about 1,715 lbs. coal.

One cord air dried beech, red oak or black oak weighs about 3,250 lbs., and is equal to 1,450 lbs. lbs. coal.

One cord air dried poplar (white wood), chestnut, or elm weighs about 2,350 lbs. and is equal to about 1,050 lbs. coal.

One cord air dried average pine weighs about 2,000 lbs. and is equal to about 925 lbs. coal.

From the foregoing it is safe to assume that 2¼ lbs. of dry wood are equal to one lb. average quality of soft coal, and that the full value of the same weight of different woods is very nearly the same—that is, a pound of hickory is worth no more for fuel than a pound of pine, assuming both to be dry. It is important that the wood be dry as each 10 % of water or moisture in the wood will deduct about 12 % from its value as fuel.

Q.—Which is the heavier, steam or air?

A.—Twenty-seven thousand two hundred and twenty-two cubic feet of steam weighs one pound; 13,816 cubic feet of air weighs one pound, so you see the air is the heavier.

Q.—If you have 100 lbs. of steam in boiler what pressure would it be at the steam chest?

The pressure in the steam chest depends on the load of the engine. When the engine is running light the pressure is reduced by the governor and the heavier the load the more reduction in speed and the farther the governor valve opens and the greater the pressure in the steam chest. On a real heavy load the steam chest pressure may be within a few pounds of boiler pressure, although the average pressure may not be much more than 50 per cent. of boiler pressure.

Q.—Is there any objection to tapered waist boiler for traction engine? If not, why are they not all made that way?

A.—There is no objection, neither is there any special advantage in a tapered waist boiler for a traction engine. This would simply be a matter of design.

Q.—What is the best way to splice an endless Gandy drive belt about seven inches wide?

A.—Make the length of the splice four times the width of the belt. Divide the splice into as many equal parts as there are plies in the belt. Cut one ply or layer off the entire length of the splice, then cut off each layer one space less so that the end space will be but one layer or ply thick. Do this on each end and fit it together so that the thin part of the one end comes to thick part of the other end of the belt. Then sew the belt with a strong waxed thread, such as shoemakers would use to sew on a sole. Run the seams lengthwise of the belt about one inch apart.

Q.—How can I remove the flywheel from an engine crank shaft that is stuck fast? It is fastened on with a key, but I cannot move either one.

A.—Build a quick fire under the hub of the flywheel; a blow torch would be a good thing to use. Heat the hub as much as feasible without heating the shaft. In this way you will expand the hub and you can drive it off, or you can get the key out more easily.

Q.—If I make my smoke stack say a foot longer, could I run with a larger exhaust nozzle?

A.—The draught in a short stack depends on the velocity of the exhaust steam and a foot more stack would not help matters unless the stack is too short. It should not be less than three feet long.

Q.—How can the brass lining be taken out of the water cylinder of a Moore steam pump and a new one put in?

A.—We would advise cutting a groove clear through the lining for the entire length of the cylinder. It can then be sprung loose and taken out. The new one should then be put in place, and with a block on top of it, drive it in place with a hammer, taking care that it is perfectly true and not one sided.

Q.—My heater is limed up and is useless. The pump is a Marsh and the exhaust steam is turned into the feed water after the pump is started. Would it injure the boiler any to feed the water in some other place and not use the heater? Please explain this fully.

A.—It will be to your advantage to clean out your

heater as it is more economical to force the water through an exhaust heater. The boiler will not be injured by not using a heater. The proper place to put the water into the boiler is on the side, near the front head.

Q.—Which traction engine is more powerful on the road, the one having a high drive wheel the other a low one, both engines having a speed of 225 revolutions per minute; traveling the same speed on the road, this being obtained by different sizes of gearing? Both engines being of equal horse power.

A.—Theoretically they will be the same. The engine having the larger drive wheels may have the advantage on a bad road, such as sand or soft ground, for more surface of the wheel will be in contact with the road and when the wheel sinks into the soft ground, a greater number of cleats will be in contact which will give the engine a better footing; but on hard roads there will be very little difference in the efficiency and no difference in the power the cylinder exerts on the traction wheels.

Q.—Is there any difference in water, i. e., in lasting longer, also making steam? Which will make steam the quickest, soft or hard water, or is there any difference?

2.—Why do they not use two safety valves on traction boilers?

3.—Will the soot from the boiler make good paint for the same, mixed with linseed oil?

A.—Hard and soft water will steam alike.

2.—The law does not call for two safety valves on

a traction engine. Some cities require two safety valves for stationary boilers.

3.—Lampblack, which is a soot from the smoke of resin, which is an inflammable solid of vegetable origin, makes the best black paint and is cheap. The soot from a boiler will be very coarse and will likely have few of the properties of lampblack. If it would make a paint it would likely be of a very inferior quality. We would advise you not to use much of the boiler soot for a trial. However, it will be interesting for you to try a little.

Q.—We have a Crosby steam gauge on our engine. When we pulled in and cleaned out the pointer stood at 0, but since then the pointer has traveled completely around the gauge, stopping within one-half an inch of the pin. Would it be all right to set the pointer on other side of pin or let it go at that?

A.—Your gauge must have been full of water and has been frozen up. It is very likely bursted; which you will find out the next time you steam your boiler. The part which is strained is the spring which is made of a flat tube; and even if this spring does not leak, the mere setting back of the hand will not do, as there is a pinion on the hand shaft, which engages into a sector, and the position of the hand would indicate that the pinion is about to the end of the sector. If the spring is strained by frost it should be put back to its original shape; this will bring the pinion to the right end of the sector. To get the gauge to register accurately again it should be tested and ad-

justed, and if there is much out of place about it the best plan would be to send it to the gauge factory where they will make it as good as new for a very small sum of money.

Q.—I use an ejector to transfer my water from the wagon tank to the engine tank. The ejector heats the water so that the injector will not work the water. What can I do to prevent the water from getting so hot?

A.—After the water is started by the ejector turn the steam off until it almost stops working. In other words, use as little steam as possible to do the work. These machines are made to lift water 15 or 20 feet and the steam pipe and steam jet is large. The ejector should be designed with small steam pipe and possibly small steam jet when it is not required to lift the water.

Q.—Have read a great deal about babbitting wrist boxings and crosshead boxings, and I want to know just how it is done.

A.—Brass is better than babbitt for the crosshead end of the connecting rod and babbitt is better for the crank pin

A brass box can be filed out to make room for the babbitt. There is no use in much room at top and bottom, but for an ordinary size engine there should be about three-sixteenths to one-fourth of an inch room at the ends for babbitt. Heat the boxes and with a soldering iron and acid cover the inside surface with solder or tin. Then put the box in place

and while it is hot pour the babbitt into box, which will unite to the metal of the box.

Too much cannot be said in favor of a filled box of this kind. It will not heat so quickly and will stand more neglect than a brass box.

Q.—My flywheel has three spokes broken all together. Is there any way to mend it, if so tell me how?

A.—A piece of flat wrought iron may be riveted on one or both sides of the broken arms. If the arm is broken near the hub, so that rivets cannot be used, the iron can be bent at right angles to fit in the corner and cap bolts can be screwed into the hub. If it is broken near the rim, either bolts or rivets can be used. A good blacksmith will know the size of iron to use, which will depend on the size of the arm.

Q.—If a quantity of water is converted into steam what is the weight of the steam as compared to the weight of the water?

A.—Everyone who is accustomed to reading engineering papers or books is constantly meeting the expression "weight of steam," and many of them are puzzled to understand how the gas steam can have weight that would be felt on weighing scales just the same as a gallon of water. Yet there is nothing more certain than the fact that a gallon of water converted into steam will weigh the same as it did before heat was applied to do the evaporating. If you put a gallon of water into a closed vessel and put a spirit lamp or other source of heat under it, and transmit sufficient heat to convert all the water into steam, it

will weigh the same as the water did. But, if the steam was permitted to expand to the pressure of the atmosphere, it would occupy 1,664 times the space that it occupied as water. The fact that it now fills much greater space does not in the least change its weight.

In the process of converting water into steam, the heat applied has no influence on the weight of water or steam. The mass remains the same weight it had in the beginning. This proves the fallacy of an ancient belief that heat was a material substance that passed from a cold to a warm body and added its own weight to the latter.—Locomotive Engineering.

Q.—What is the best way to grind globe valves and stop cocks?

A.—Use oil and emery or fine sharp sand screened through a piece of goods or bolting cloth. In the case of a globe valve, after the valve is taken apart, the valve disc should be fastened to the stem, if it is of the loose type, this can be done by taking the disc off and putting a piece of cardboard between the disc and stem. If it is a regrinding valve, the bonnet or part that has the stuffing box can be put back, which will guide the stem while grinding. The stem can be revolved by a brace or by hand, taking hold of the hand wheel. If it is not a regrinding valve, screw the bonnet up on the stem, and proceed to grind it by holding it as near central as possible. Always take the valve from the seat before attempting to screw the bonnet off on a valve that is not of the regrinding type, as you will be sure to ruin it if you do not

observe this. A stop cock should be drawn out occasionally while it is being revolved so as to not cut grooves around the plug seat.

Q.—Why is it best to use hot water in testing an engine with hydrostatic test?

A.—Hot water is used in testing boilers, to expand the metal and to get the boiler as near to working conditions as possible.

Q.—Why does a pop safety valve open wide, reduce the pressure in the boiler and then suddenly close down?

2.—Why does the water in a glass gauge register higher after it is blown out than it did just before?

A.—There is a flange or lip on the valve which is larger in diameter than the hole in the seat and when the steam raises the valve to let the steam escape the steam strikes this flange or lip and drives the valve still farther up against the spring until the pressure is reduced enough to allow the valve to start down to the seat and as soon as the flow of steam is reduced the spring snaps the valve to its seat.

2.—This is more noticeable in winter when the temperature of the atmosphere is low. When the water is cold in the glass it registers lower than it is in the boiler on account of it being heavier; and when the water is blown out of the glass and hot water is allowed to come into it, the hot water being lighter will fill up higher in the glass.

Q.—What makes our cylinder boxes heat, and what is the best oil to use on them?

A.—A cylinder box usually heats from getting

out of line. Cylinder oil mixed with graphite is very good to smooth the bearing and get it to run cool.

Q.—Is it a good idea to paint a Gandy belt with red lead and linseed oil?

A.—To keep a Gandy belt painted as you suggest would prolong the life of it.

Q.—Please tell me how to re-babbitt the counter-shaft of a Gaar-Scott engine. The engine is of the external gear type. Also the best way to babbitt an Indiana blower fan shaft.

A.—To re-babbitt a box, the old babbitt should all be taken out; care should be taken to get it out of the cavities which hold the babbitt in place. The shaft should then be put in its proper place, when there is gearing on the shaft, the teeth should be put in mesh and held there, this can be done by blocking up the shaft to hold it in place while the metal is poured in the box. The metal is then dressed so that the shaft fits loosely; this is necessary on account of the shrinkage of the babbitt metal. The cap is then put on the box, placing the liner, (made of cardboard or heavy paper) between the box and cap. The metal is then run into the cap, which is also dressed, due to the shrinkage of the metal. The oil holes may be drilled in after the box is poured. A pin of wood, which should touch the shaft, may be put in oil hole before pouring; this will leave a good oil hole after the pin is driven out and will save drilling.

Q.—In a bevel pinion compensating gear, do both

drive wheels pull on a straight pull and when going around a corner? If so, what are holes for lock pin in compensating gear for?

A.—In a compensating gear the pull is the same on both wheels, although one may be turning faster than the other, as in going around a corner. See article in appendix explaining this.

In a mud or sand hole one wheel may have so much better hold than the other as to cause the latter to slip and spin helplessly under the compensating gear. Locking them together by means of the pin causes the power to be transmitted direct to both wheels, thus making use of the anchored driver.

Q.—Will an eight gauge saw run much lighter cutting a ¼-inch kerf than 6 gauge saw with same kerf in hard wood?

A.—There should be no difference if all conditions are good in both cases. However in the case of the 6 gauge saw everything must line up better than with the 8 gauge saw as there is but little less than 1/16 of an inch clearance with the 6 gauge saw and as much more than 16 inch clearance with the 8 gauge saw.

Q.—Which is correct, to say steam is a vapor, or steam is a gas?

2.—When speaking of cold what is meant by zero, and twenty below zero?

3.—When speaking of heat, what is meant by 80° F?

4.—What is the line between heat and cold?

5.—What is meant by Fahrenheit?

6.—What is the degree of "commence to boil?"

7.—What is freezing point?

8.—What is the unit of heat?

A.—We speak of steam as a vapor when it is exhausted in the atmosphere where it can be seen, and as a gas when it is under pressure, especially when it is superheated; by this we mean when saturated steam, or steam produced from a boiler in the regular way, is heated beyond the temperature indicated by its pressure.

2.—On the instrument to measure temperature, called the thermometer, there is a scale with degrees marked along the side of a column of mercury or spirits. This mercury or spirits expands or contracts as the temperature changes. When the top of the mercury is at 32° the temperature is at the freezing point and when it is 32° below freezing point it is at zero or (0). When the temperature gets colder than zero it is called below zero. In this case the top of the mercury column goes below this point.

3 & 5.—There are three kinds of thermometers: Fahrenheit, which is used in English speaking countries, and takes its name from its inventor; the Centigrade, or French thermometer, which is used in countries that use the metric system, and the Reaumur thermometer, which is used in Russia, Sweden, Turkey, and Egypt. So 80° F. means that a Fahrenheit thermometer is used.

4.—There are two kinds of heat, viz.: sensible heat and latent heat. There is some heat in zero weather, but not so much as at the freezing or boiling points.

The point where there is no heat is at absolute zero, which is 459.4° below zero Fahrenheit.

5.—Water boils at 212° F. at the sea level at atmospheric pressure, or 14.696 lbs. per square inch.

7.—Freezing point is 32° F.

8.—A British unit of heat—B. T. U.—is the quantity of heat which is required to raise the temperature of one lb. of pure water, 1° F., at or near 39° F.

Q.—The flywheel on my engine has a straight face and when it is windy weather it is very hard to keep the belt on the pulley. I would like to know if there is some way to make an oval face pulley out of it without sending it back to the factory? Also, do you know how pulley covering is in wet weather? Does it get slippery, so a belt will not stick, or is it all right?

A.—If the flywheel has a straight face, a crowning face may be had by covering the wheel with leather. Drill holes in the rim and rivet a leather belt to the face. First put a narrow strip in the center of the wheel, skived down on each edge, so that when the covering is put on, it will make the proper crown. Another way to get the shape is to wrap tightly the face with cord until the desired crown is had; the covering with the leather belting together with the rivets will hold the winding of cord in place.

There is nothing that will make a better driving contact for a belt than a leather covering.

Q.—I have a jet pump of my own make, and notice that the temperature of the water delivered is

much higher when steam pressure is low than when it is high, temperature of water at suction being the same in both cases. Why is it?

A.—You will notice that you have to turn the steam valve open farther when the pressure is low. When the pressure is higher, the steam has a greater velocity and less of it is required. Another reason is that there is more heat in a low pressure of steam in proportion to its pressure than in a high pressure. That is, the heat in the steam does not increase as rapidly as the pressure.

Q.—Will a good one-inch rope have strength enough with a single block to pull a late improved separator up any grade of a bank barn?

A.—A hemp rope of one inch in diameter is capable of drawing three tons; and should be strong enough for the work mentioned.

Q.—The flywheel on my engine runs out sidewise. I was told that I could get it true by refitting the flywheel key, but am unable to get the key out. Can the wheel be straightened any other way?

A.—You can pene the arms to make it true. By this we mean to stretch the surface of one side of the arms which will bend them. While the engine is running, hold a piece of chalk against each side of the rim of the wheel, thus marking the projecting part of the rim. Now turn the mark on the side next to the boiler down, or at a convenient place so as to get a pry between the boiler and the flywheel at the middle of the chalk mark. This will put the wheel on a strain in the direction in which it should

go. Now strike the arms close to the hub, in line with the chalk mark, with a pene hammer, so as to stretch that side of the arms; then go to the other side and pene the other half of the arms in line with the chalk mark on that side. The stretching of the arms on both sides will tend to get the wheel true. Give it a moderate amount the first time and rub the chalk mark off and remark it, keeping close watch as to the effect it is having. The wheel is so easily bent in this way, that one is liable to give it too much the first time. If it is bent too much it can easily be sprung back with the pry or it can be bent back by peneing on the other side of the arms.

Q.—Is it a good practice to run the main drive gear which runs the ground wheel on a traction engine in oil by placing a pan under it?

A.—If there is simply a pan to hold the oil, mud and dust will drop into it and get mixed with the oil and will therefore wear or cut the gear very rapidly. If, however, the whole gear is cased in, so that dirt cannot drop into the oil pan, it will be a very good thing for the gearing.

Q.—How much hotter is the fire that is usually in the firebox of a boiler, than the water in the boiler?

A.—The temperature of the fire or flame can be determined by its color. Faint red is 960° F.; bright red, 1,300°; cherry red, 1,600°; dull orange, 2,000° bright orange, 2,100°; white heat, 2,400°, and brilliant white heat, 2,700°.

These high temperatures can only be had by forc-

ing the fire with a strong blast. The lower temperatures apply to the fire in a boiler, and only to the live coals and flame. There are hot gases which cannot be seen and which are less than 960° (the temperature of faint red) but do much in heating the boiler. The temperature of the water at 150 lbs. of steam, gauge pressure, is about 365°.

Q.—There has been much dispute around here among threshermen as to whether a machine runs easier or harder when the engine is set higher or lower than the machine. My theory is that there is no difference; but most of the threshermen around here vehemently declare that a machine runs much harder when the engine is set lower than the machine, both being leveled, of course. Would be pleased if you would answer in regard to this.

A.—There will be very little difference either way. When the engine is set higher than the machine the thrust of the belt takes some weight off one end of the cylinder bearing and when set lower or level it puts additional pressure on the bearing. To make the case plainer, suppose the engine to be directly over the machine, this would be quite effective in relieving the friction of the box caused by the weight of the cylinder; and if the engine were directly under the machine, this would have the same effect as if it pulled in a horizontal position. So far as the machine is affected, having the engine higher is a help, and having it lower makes little difference from a horizontal pull, except that the lower the engine is the more of the weight of the belt is carried on the

cylinder shaft It will be easily seen that when the belt is horizontal, half the weight of the belt is carried by the machine, and when it is vertical the whole weight of the belt hangs on the machine. However, the case will average up for the engine and machine are always affected in an opposite way when one is higher or lower than the other.

Q.—What is the best way to repack the steam chest cover?

2.—Is there any law against running an engine without steam gauge or safety valve?

3.—What is the best way to regrind a check valve?

4.—How can I regrind a globe valve that has a loose disk?

A.—Any kind of packing will do for packing a steam chest cover. The thinner the better as this packing is not so apt to blow out. A sheet of any kind of heavy paper is a good substitute for regular packing in case of an emergency.

2.—Some cities require two safety valves on a boiler. While there may be some places where there is no specific law on this point, yet there would be a law to punish any one who would destroy life and property, caused by the explosion without these appliances of safety.

3.—Fine emery or sand and oil is good to cut the metal and a bit brace is a good thing to turn the valve. In some cases the valve has a slot in the top, so that it can be turned with a screw driver. In other cases the valve can be fastened in a piece of wood

and the wood turned by the brace. If there is no room to turn a brace the stick or screw driver may be turned with the hand. This is a little more tiresome, as the power can not be applied as with a brace.

4.—Take the disc off and put it on a stick of wood to grind it, or fasten it on the stem by placing a piece of hard board between the disc and the end of the stem and then turn the valve by the stem to grind it.

Q.—At a recent assemblage of engineers in our vicinity the question arose as to the difference in pressure at different parts of the boiler; i. e., any square inch in the dome and any square inch in the bottom of the boiler when the steam gauge registers 100 lbs. pressure.

A.—There will be more pressure in the bottom of the boiler due to the height of the water. At 100 lbs. of steam (gauge pressure) the temperature of the water would be about 337.8°. At this temperature the water will weigh about 0.347 lbs. per square inch of one foot in height. For example, if the water is four feet high in the boiler, the weight of the water per square inch would be 4×0.347 or 1.3888 lbs., which added to the 100 lbs. of steam would be about 101⅜ lbs. pressure on the bottom of the boiler when there is 100 lbs. above the water line.

Q.—We have a Crosby steam gauge on our engine. When we pulled in and cleaned out the pointer stood at 0, but since then the pointer has traveled completely around the gauge, stopping within one-half an inch of the pin. Would it be all right to set the pointer on other side of pin or let it go at that?

A.—Your gauge must have been full of water and has been frozen up. It is very likely bursted; which you will find out the next time you steam your boiler. The part which is strained is the spring which is made of a flat tube; and even if this spring does not leak, the mere setting back of the hand will not do, as there is a pinion on the hand shaft, which engages into a sector, and the position of the hand would indicate that the pinion is about to the end of the sector. If the spring is strained by frost it should be put back to its original shape; this will bring the pinion to the right end of the sector. To get the gauge to register accurately again it should be tested and adjusted, and if there is much out of place about it the best plan would be to send it to the gauge factory where they will make it as good as new for a very small sum of money.

Q.—If water boils at different degrees of heat at different altitudes, why does it not have different degrees of heat under different or varying pounds of steam in the boiler, and what is the temperature of the water at 100 lbs. steam pressure?

A.—The water in the boiler has more heat in it as the steam pressure increases. The water boils in the boiler at atmospheric pressure and has 212° of heat. At 100 lbs. gauge pressure it has 337°, and at 200 lbs. gauge pressure, 387°, and so on. See table "Properties of Saturated Steam."

Q.—I have Kunkel Pop valve on 16 h. p. boiler set to pop at 135 lbs. When the pressure gets to 120 lbs. it begins to leak steam, and continues to until it

reaches 135 lbs. Then it will pop, till the pressure is reduced 15 lbs. and close all right and at once begin to fizz again. I would like to carry 130 lbs. without any loss. How can I remedy this? Engine has been in use two years, valve worked that way from first start.

A.—The valve may be of an inferior make. Some valves have a loose lip on the seat which can be adjusted. To make it pop quicker and not blow down so much, the lip should be raised. If there is no such arrangement in your valve you likely cannot do anything for it. A new valve may be the only thing that will help you.

Q.—How shall I set or change a pop valve with two hexagon nuts at top?

2.—In a cylinder used six years is it better to buy new rings or have some made large at shop? The cylinder is cast to engine frame, which is fastened to boiler with cap screws and it is almost out of question to remove it here for reboring.

3.—Will you give directions for operating a Moore steam pump and kind of packing to use?

A.—You will find on the valve a bolt head and jamb nut. Loosen the nut and screw the bolt down for more pressure and then make tight the jamb nut. About one-sixth of a turn of the bolt will affect the valve five pounds.

2.—The use of an engine six years should not wear the cylinder so large that it would necessitate having rings made larger than standard size. In case of a cylinder which is larger than standard size,

larger rings may be ordered by making a gauge and sending it to the factory. Cut a piece of one-fourth inch round iron to a length that will fit the cylinder. The ends should be rounded over and the piece should be bent so as to just fit the cylinder. This can be sent through the mail and will be more satisfactory than trying to give the exact size by the fraction of an inch.

3.—In starting a steam pump turn the exhaust into the atmosphere and open the pet cock on the valve chamber of the pump, to exhaust the air in the pump and suction pipe. After the water flows from the pet cock, close same and then turn the exhaust steam into feed water by the valve provided for the purpose. The water piston packing is rubber rings especially prepared for the purpose and are furnished by the pump maker or party which furnished the engine. Any kind of ordinary packing will do for the stuffing boxes.

Q.—Why is it that a traction engine whose axle is placed behind the boiler, will not pull a load backwards on soft ground or deep sand?

A.—Whether the axle is at the rear end or middle of the firebox it will not pull as much backward as going forward. Yet there is some difference in engines. An engine that is easy to rear up in front while pulling a load going forward will not slip its drivers pulling backward. Neither rearing up in front and pulling forward, or slipping the drivers pulling backward is desirable. An engine should be balanced so that it will do both kinds of work well

and there are engines built with the axle at the rear and some with the axle located on the side of the firebox, that do both kinds of work well.

Q.—Tell me which will give an engine the most power; to screw the governor down or up to climb a hill?

A.—Since screwing the governor "down or up" does not change the relation between the cylinder and the traction wheels, there will be practically no difference in the load the engine is capable of pulling, that is, within a reasonable range of speed. However, at the higher speed the engine will pull a smaller load than at the lower speed, for more of the power is used up by extra friction due to the speed. The cylinders will develop more power at the higher speed and greater power is required to pull a load at high speed. So changing the governor so that the engine runs faster it will develop more power, but will pull a smaller load.

Q.—My steam gauge is located over the firebox. It has a brass syphon, It seems to get full of thin mud about like putty and then it won't register right. I have cleaned it out several times. You would naturally think I use very dirty water, but I do not. I keep the boiler reasonably clean, but have to work it pretty hard; only about nine feet heating surface per horse power. Where is the best place to attach it? The engine is a 12 h. p. traction.

A.—The sediment which looks like thin mud is likely carbonate of lime which the heat extracts from the water. The gauge pipe must extend down

through the boiler into the water. You could change the piping of the gauge so that it is directly connected to the steam. If you could set the gauge from the dome of the boiler, it may be that would be a more satisfactory place for it. A good syphon is needed when the gauge is connected directly into the steam part of the boiler.

Q.—Is there anything saved in hooking up a valve if the governors are in perfect order?

A.—The governor, if in perfect condition, will not answer for hooking up the valve gear. The steam should be cut off early in the stroke and then work on the expansion of the steam the balance of the stroke. The earlier the cut-off the higher the pressure in the cylinder and the greater the expansion. The governor can not help in the economy but simply keep the speed regular.

Q.—Why would it not be a good plan to have the front wheels of a traction engine driven as well as the rear wheels? Would it not pull better?

A.—There would be some advantage on the pulling but the additional cost of the engine driven this way would not warrant it. In pulling a load the weight of the engine is thrown on the rear wheels and the front wheels would do little good as a driver. However, in backing a load the weight would be thrown to the front wheels and here is where it would be of the most service. Since an engine is used so little for backing, it is not worth considering. Another point is that the engine would be made much heavier by this arrangement, as the gearing

and axle would have to be made strong, for in case of backing a load the work might be as severe as on the rear wheels going forward.

Q.—While engine is running slow and pulling very hard doing traction work, it will run smooth and quiet. When it is running fast, threshing, it pounds terribly. Tightening the crank-pin and crosshead box does not help it any. If the crank-pin is worn out of round would that cause it? There is a good hand oil pump on steam chest, so have used enough oil to satisfy me that the trouble is not in the cylinder. Have been very careful in taking up the slack in all the other places.

2.—Which is the best kind of steam gauge, single or double springs?

A.—The crank-pin being out of round will certainly have something to do with the trouble. It may be your crosshead is out of line or the crosshead loose in the guides. The engine will naturally run better when running on the road on account of the engine running over and when threshing the engine runs under, which will exaggerate any trouble in the guides or crosshead beside the harder pull while threshing.

2.—The double spring steam gauge was designed for traction work to stand up under the excessive jarring it gets in this service.

Q.—What kind of packing is there in the gland between the high and low pressure cylinders of a Woolff compound engine, and how often does it need renewing?

2.—How does an engineer change his valve for plowing to gain anything more than to have it set right? I hear some say they always set it different for plowing than for threshing.

3.—Will the location of the exhaust nozzle have anything to do with foaming?

4.—What is up or down location in the stack?

A.—There is metallic packing between Woolff compound cylinders. We copy herewith instructions from the Huber Manufacturing Company's repair list.

The metallic packing between high and low pressure cylinders should be examined once or twice a year. Take out the center head and examine parts well, before putting center head back to its place, scrape or clean out any accumulation that may be found. Be sure to tighten set screws alike, draw them up tight.

2.—There is no difference in the setting of the valve in an engine. When it is right for plowing it is right for any other kind of work.

3.—The location of the exhaust nozzle has nothing to do with the foaming of the boiler.

4.—In some engines the exhaust nozzle extends up to the stack; in others it is below the bottom of the stack.

Q.—How will I find the dead center on a simple engine?

A.—In the accompanying drawings *A* is the crank, *B* the crosshead and *C* a compass or pair of dividers. Turn the engine from the end of its travel about one-

fourth of the stroke with the crank-pin above the center line of the engine as in Fig. 1. Make a center

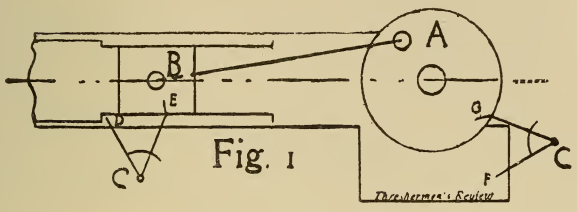


Fig. 1

mark in engine frame at *D*; place the compass in *D* and make a mark *E* on crosshead with compass fixed so it cannot move throughout the whole operation.

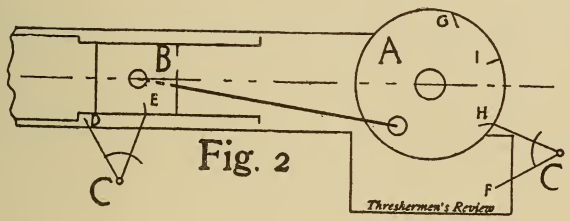


Fig. 2

Make a center mark at *F* at a fixed point on the frame or some convenient spot; place in *F* and make the mark *G* on crank with com-

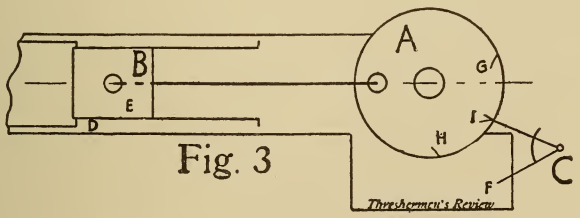


Fig. 3

pass. Then turn the crank-pin below center line of engine as in Fig. 2, so that when com-

pass is in center mark *D* the mark *E* will come to the other point of the compass. Place the compass in center mark *F* and make the mark *H* on the compass. Then find the point *I* which is midway between *G* and *H* which should be gotten with another compass, so as to not disturb compass *C*. Now turn the engine until the point *I* reaches the one point of the compass when the other point is in the center mark *F*. The engine is now on dead center.

The other center is gotten in the same way using new points instead of *D* and *E*, but using the same point *F* and *I*, and the same setting of the compass. A good plan is to make a fixed compass out of heavy wire or light iron rod with sharp points bent as in

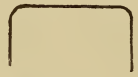


Fig. 4.

Fig. 4. If the engine is of the center crank type, the marks *G*, *H* and *I* can be made on the flywheel which will answer the same purpose.

A good plan is to rub chalk on the places where the marks are made by the compasses so they can be more readily seen.

Appendix.

When Safety Appliances are Unreliable

The statement that the crown sheet of a boiler in service should not be allowed to get bare of water, even for the shortest time, will appear a truism to thoughtful and experienced threshermen. And yet, as a crown sheet failure described by a Review reader in our correspondence columns shows, there are men in charge of steam boilers who do not have a proper appreciation of this fact or of the danger incident to a disregard of it. It may be that in this particular instance, as in others, too much dependence was had upon safety appliances which should have worked and did not; and this leads us to a consideration of such appliances and the conditions under which they may become inoperative.

In the instance described, there seems to be no room for discussion regarding the cause of the failure. It is a plain case of overheating the sheet; a condition of which the safety plug should

have given warning long before danger point was reached. That it did not may be due to several causes; it may have been melted out before and, instead of being replaced with a new one the opening may have been plugged up with something else as an expedient and then forgotten. Or scale may have accumulated over it thick enough to withstand steam pressure even with the filling melted out. To be effective as a danger signal the safety plug must be in its proper place, and its water end must be kept clear of scale so that it can respond promptly when called upon.

The safety plug, however, should not be depended upon as a normal safety device, and its warning could only come as the result of gross neglect on the part of the boiler tender. On every boiler there are or should be at least two sets of appliances for keeping watch of the water level: the glass water gauge and a set of gauge cocks. The lowest of the cocks and the lower end of the glass gauge are set above the level of the crown sheet, and under normal conditions they may be depended upon to indicate the exact water level.

There are conditions, however, under which they, and particularly the glass gauge, may become inoperative or misleading and these will be considered in the following.

As will be remembered, the glass gauge consists of two fittings screwed into the boiler and connected by a glass tube into which the water and steam flow through the fittings, indicating the water level, the

fittings being so placed that the water, at its proper level, shows about the middle of the glass. Both fittings are supplied with valves for closing the connection to the boiler in case of accident to the glass, and the lower one with a drip cock for emptying the glass when occasion requires. The steam pressure through the upper valve being the same as in the boiler, the water level in the glass is not influenced by it.

Now let us suppose the boiler to be empty and the upper valve closed. Then, though the water could run into the glass through the lower valve, the upper one being closed, the air confined in the glass would prevent the water from rising beyond a certain height and the glass would show no more, even though the boiler were filled to the top. If the condition were reversed and the lower valve closed with the upper one open, then the water would reach the level of the upper valve opening before it would flow into the glass.

Or suppose both valves have been open when filling the boiler and that one of them has accidentally been closed while steam is being raised. If the upper valve, then because there is no chance for steam to get into the upper end of the valve, its pressure will force the water through the bottom opening until the glass is nearly filled; showing a much higher level in the glass than really exists in the boiler.

Supposing our thresherman fires up in the morning with the water showing at, say, half a glass, and with the lower valve closed. Then the water will

remain at the same height in the glass—it may rise a little from condensation of the steam entering at the upper end—while all the time it is getting lower in the boiler. Unless the operator is careful and observing this condition might result in serious damage to the boiler before it is discovered.

Now let us assume the boiler to be under steam and that for some reason the steam passage to the water gauge is so small that the steam has not a free passage, but can just ooze through into the glass. This might be through insufficient opening of the valve or by the boiler passage being choked up with scale. Then, because it can flow in but very slowly, the pressure of the steam over the water in the glass is reduced; and this will allow the water to rise higher in the glass than its level in the boiler. A very slight difference in the steam pressures will make a considerable difference in the water level in the gauge.

There is another condition which, although not likely to occur in traction engine practice, is of interest in discussing water gauge troubles. Suppose that the boiler openings are clear and the valves open, but instead of attaching direct to the boiler the fittings are made by means of pipe connections placed some distance from it. With cold water in the boiler the level would be correctly shown. But with rising steam pressure the indication would be different. The pressure of steam depends upon its heat; so that if its temperature is lowered its pressure is also lowered. Now in the fittings close to the boiler the

steam temperature is practically the same; but as it flows through the pipe it gives up some of its heat with a corresponding reduction of pressure; resulting in the water being forced higher up in the glass than its level in the boiler; making the glass show a higher water level than is really contained in the boiler.

The principle cause of trouble with the glass water gauge on a traction engine is closure of the water or steam connections either by scale or dirt or by forgetfulness in the matter of the valves. It is a good practice to test water gauges at least once every day. This may be done by closing both upper and lower valves, opening the drip cock on the bottom fitting and then opening and closing each valve separately, allowing it to discharge through the drip. If the discharge from either is not free the defect should be remedied at the earliest opportunity.

The engineer should train himself not to depend solely on the water glass. The gauge cocks with which the boiler is also fitted should be regularly used, and the water level should be such that no steam can be drawn from the lower one. There is nothing about them to get out of order, and they only require to be kept tight and free from scale or dirt. With these and the water glass in good order the operator can always keep himself informed regarding the water level and can avoid the risks incident to uncovering of the heating surface of the boiler. Should this occur either by accident, as in the case related by our correspondent, or otherwise, then no time should be lost in closing dampers and covering the fire either

with plenty of coal or with dirt, so as to avoid unduly heating the exposed surfaces, until the proper water level can be restored. Do not attempt to draw the fire. This will only result in stirring it up and making it burn more fiercely, thus increasing the danger it is sought to avoid; while promptly smothering it by covering it as already described, with all drafts closed will abate the intense heat that would otherwise weaken the furnace plates and cause a rupture. Under no circumstances should water be thrown into the firebox to put out the fire. The consequent sudden and unequal contraction in a perhaps already overwrought sheet is likely to bring about the disaster it is sought to avoid.

The Steam Engine Indicator.

The man with a taste for machinery finds much interest and pleasure in watching a well made, well kept steam engine at work. The mechanism is so exact in its movements, so regular in its pulsations, so suggestive of power and yet so sensitive to control, so instinct with life as to seem a living, reasoning being instead of a mere mass of senseless metal shaped into a harness for the subjection of the mighty power of steam to man's uses.

As he watches the engine in its steady, easy performance of its heavy task he comes to an appreciation of the well nigh resistless force at work within the engine cylinder; unseeing and unseen, yet doing itc work with marvellous celerity and precision. Reflecting on these things, it would be but natural that he indulge in some speculation with regard to just what is going on within those windowless iron walls; what is happening there during each stroke of the piston and at every part of its stroke; whether the pressure is being applied heaviest just when it will do the most good; what happens when the valve shuts out the supply of steam; in short, exactly what is going on at every instant of time in the closely sealed engine cylinder.

All these things might well suggest themselves to the person with a leaning toward mechanics, yet

only casually interested in the care and management of a steam engine. To the man actually in charge, however, they are matters of vital importance, for upon his accurate knowledge of them depends much of his success in controlling the mighty forces he has under his care. He can hazard no guesses, indulge in no uncertain speculations; he must be able to know to a certainty that everything is right, or to verify his belief that something is wrong, and to locate the cause. And to aid him in this a very effective instrument has been devised: the steam engine indicator. Though an instrument of precision it is not a complicated affair. It depends for its operation upon some properties of steam, a knowledge of which will give us a clear understanding of the principle upon which it works. Before describing the instrument in detail we will therefore enter into some

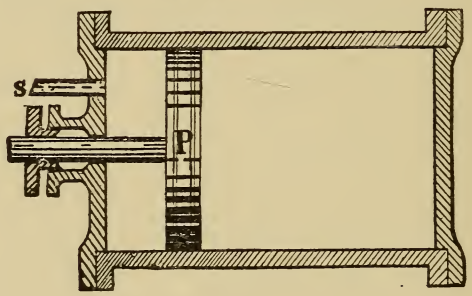


FIG. 1.

explanation of the properties of steam just referred to.

Let us take, for example, an engine cylinder with, say, a 9-inch piston and 12-inch stroke; and for better illustration let us suppose it without valves or

ports, as in Fig. 1, also ignoring the area occupied by the piston rod, and that the piston fits tight in the cylinder and snug up to the piston head. Now let us admit steam at 120 lbs. pressure through the pipe, *S*, allow it to push the piston ahead for three inches and then hold it there, as in Fig. 1. The space between piston and head is now filled with steam, and if we had a gauge screwed into the top of the cylinder and opening into this space it would register 120 lbs. Still ignoring the space occupied by the rod, the area of the piston is 63.62 inches, and the space now occupied by steam at 120 lbs. pressure is $63.62 \times 3 = 190.86$ cubic inches.

Now let us shut off the steam at *S* and then allow the piston to move forward another three inches. The steam, at first confined in the three-inch space, now occupies $6 \times 63.62 = 3881.72$ cubic inches; and the pressure now indicated by the gauge, assuming that the temperature of the steam remains the same throughout this experiment, will be just half what it was before: 60 lbs.

With the pipe at *S* still closed, let us move the piston forward still another three inches. The steam now occupies three times its first volume and its pressure has lowered in exact ratio and is now but one-third its first figure: 40 lbs. If we now let the piston move the remaining three inches to the end of its stroke the steam will have expanded to four times its original volume and its present pressure on the piston will be but one-fourth what it was at first, or 30 lbs.

To make this still plainer, let us suppose that the bottom line of Fig. 2 represents the length of stroke of the piston, 12 inches, which is separated into three-inch divisions by the upright lines. The space between the first two is occupied by steam at 120 lbs.,

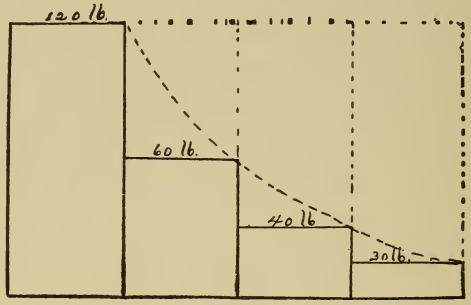


FIG. 2.

as indicated. In the next space the pressure has dropped to one-half, and so on through all the spaces; the last one showing the comparatively small effective pressure of 30 lbs. And if we could have attached a small steam cylinder to our cylinder, having a weighted piston carrying a pencil at the end of its rod so that it would drop as the pressure was reduced, and could have provided a piece of cardboard moving sideways past the pencil point as the piston dropped it would have made a line something simliar to the dotted curved line shown leading from the right upper corner of the first space down to the right top corner of the diagram.

Now the foregoing is practically what takes place in the cylinder of a working steam engine; the steam entering at full pressure until the piston reaches the

point where the valve shuts it off;—in this case three inches—the steam then working "expansively" and with constantly lowering pressure until the end of the stroke is reached, when the exhaust port opens and allows the steam to escape into the air. In order to make the explanation as easily understood as possible all reference to the differences arising from changes in temperature, and the various other things that might make an appreciable difference in our figures have been omitted. But the pressure at time of exhaust is very considerable, and since it does no further work in the cylinder, but is turned into the open air, a loss ensues varying with the condition and pattern of the engine, but considerable in any event. It is not practicable to allow the piston to travel still further and so utilize the pressure on it until none is left. This loss is best reduced to its lowest terms by using steam at high boiler pressure, so that the terminal pressure will be high enough to utilize in another cylinder and there be expanded to the lowest practical point; the compound engine.

With this understanding of some of the properties of steam we can proceed to a description of the indicator, its application and uses.

As will be seen at Fig. 3, the indicator consists of a small steam cylinder, *A*, provided with a piston which is weighted with a spring of known "weight," much as a safety valve is, the piston rod projecting through the top of the cylinder where it is attached at *B* to a lever which is moved up as pressure is put upon the piston, the spring, not shown in the cut,

bringing it down again as pressure is reduced. At the other end of the lever, at *C,* is a pencil point which presses against the revolving drum, *D,* just hard enough to make a mark on a piece of paper wrapped around the drum and held in place by the

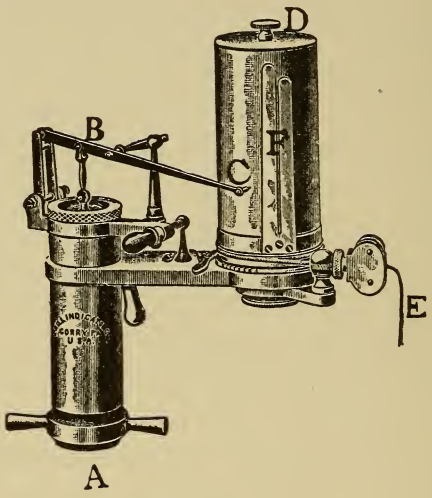


FIG. 3.

spring clips *F.* Around a pulley which is formed in the bottom edge of the drum, *D,* is wrapped a piece of stout unstretchable cord, *E,* the other end of which is connected with some reciprocating part of the engine, usually the crosshead, so that with one stroke of the piston the cord is tightened and the drum caused to make one full revolution; and upon the return stroke a spring inside the drum returns it with one revolution to its original position, rewinding the cord on its pulley ready for the next stroke. So that with every stroke of the engine piston the indicator

drum makes one complete revolution, which is timed exactly with the movement of the engine piston.

Most traction engine owners have no doubt noticed a plugged hole in each end of the cylinder, opening into the clearance space; and many have no doubt wondered what they were put there for. They are the holes that were used by the factory experts when testing the engine, and they are where the pipes leading to the indicator were connected to the cylinder. These are made as short as possible and are usually led toward each other to a three-way cock, so that communication can be had with either end of the cylinder at will. The indicator is screwed into the three-way cock, the connection being made at *A*, and with the cord properly connected with the crosshead and a strip of paper wound on the drum and fastened securely to place, the instrument is ready to work. There are some important precautions to be taken in doing all this, but since the detailing of them would occupy more space than can be given them in this article, which is intended merely to outline the nature and use of the indicator, we are omitting them here.

Now with the drum rotating with each stroke of the engine, and no steam going to the indicator cylinder, the pencil point will trace a straight line on the strip of paper wound on the drum. But with steam entering through *A* the indicator piston is forced up a distance corresponding to the pressure in the engine and indicator cylinders, and the pencil records a perpendicular mark on the paper strip. As the indicator drum is timed exactly with the engine piston, it fol-

lows that when steam is admitted to the front of the engine piston at the beginning of the stroke the pressure there will be all at once felt at the indicator piston and will force it up, and the pencil point will score a line like the first line at the left in Fig. 2. When the indicator piston has reached its highest limit it will be held there until the point of cut-off is reached; corresponding with the first three-inch mark in Fig. 2, and the revolving drum will cause the pencil point to trace a straight mark at the top of the card; corresponding with the line marked 120 lbs. in Fig. 2. When the engine valve cuts off the steam, the effect is the same as when we shut off the steam at *S*, Fig. 1.

All the steam that is to be admitted for that stroke of the piston is now in the cylinder, and as the piston moves on toward the end of its stroke the steam occupies a constantly enlarged space with a constantly lowering pressure at the end of the stroke; and as the pressure lowers in the engine cylinder the indicator cylinder follows it, and the revolving drum continues its mark, not in a straight line, as before, but in a downward curve resembling the dotted curved line in Fig. 2. When the end of the stroke is reached and the pressure falls suddenly because of the exhaust, the indicator piston also falls and the pencil with it, tracing a line corresponding with the short 30-lb. line at the right of Fig. 2. The indicator lines will not be exactly like those in Fig. 2, because that is a conventional drawing; but they will follow the exact steam pressure at every point from begin-

ning to end of the stroke of the engine piston; also recording the other pressures due to back pressure, compression, and in the case of a condensing engine, to vacuum.

That is, it will record these things if the engine is working just as it should. And the diagrams taken from such an engine will be pretty uniform and will correspond closely with what is known to be a theoretically correct diagram. If the engine is not working correctly, however, the diagram will show deviations from the normal that will indicate the trouble if due to irregularities in steam admission, expansion or exhaust; such as wrongly set valves, leaky piston or stoppage in exhaust pipe or nozzle. These and other things affect the diagram, and it's tracing will show to the experienced indicator user where the trouble lies.

As a matter of course there are many items of detail in connection with the use of the indicator that are not considered in the foregoing; this article being intended as an explanation to the unaquainted threshermen of the nature and use of the steam engine indicator and to aid him in understanding the use thereof.

Keys and Set Screws of Farm Machinery.

Some Noon Hour Talks on the Subject of Mechanics.

Keys and set screws in modern machine and tool fittings of farming implements, form one of the essential problems of mechanics. The writer has been interested in following the trend of some noon-hour talks across the dinner pail, of men who are well up in the matter of farming mechanisms of modern times. These mechanical problems differ greatly from those that confronted the designer of farming machinery and implements of a dozen or fifteen years ago. Today we find a greatly increased proportion of labor saving devices, with necessary automatic attachments to perfom the work. The increased speed, the nicety of adjustment, the generally improved appearance so as to effect a sale quicker, are all noticeable in the modern machine. But it is chiefly the problem of setting parts by means of set screws that we will discuss in this article. There is, for example, the ordinary square key, shown in Fig. 1. This form of key has been used in the securing of gear hubs, flanges, couplings, and the like in farming devices for a very long while. The flat key is also used, but does not have the substantial grip of the square key. The flat key is often driven into the key seat of the hub and

left to frictional contact to get a bite on the shaft. The result is constant slipping. The position of the square key is shown in Fig. 5 at *a*. That of the flat

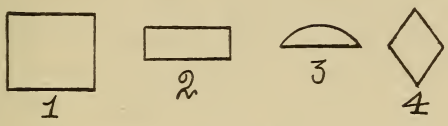


FIG. 1-4.

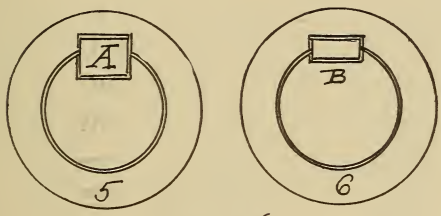


FIG. 5-6.

key, when sunken partly into both collar and shaft, is as in Fig. 6 at *b*. In Fig. 7 is shown the faulty round or half moon key that one runs across occasionally and al-

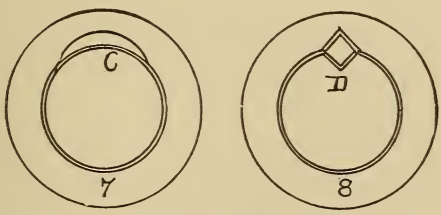


FIG. 7-8.

most immediately proceeds to cast it out and substitute a proper one. The half round key is shown in Fig. 3. In Fig. 7 is presented the method of insertion for gear, wheel or coupling. *C* points out

the position. It can be readily seen that the key depends almost entirely upon the gripping power of the rounded surfaces, and unless the parts are well fitted the trouble of slipping will occur at once. Fig. 4 is the diamond formed key which is found now and then. The manner of setting this key in place is shown in Fig. 8 at *d*. The trouble lies in the fact that the sides of the key wear quickly and soon a wabbly union results and the key slips out. Sometimes the twin-key is found in use in connections in farm machinery and the repair man, in overhauling the parts is surprised when in driving out such keys,

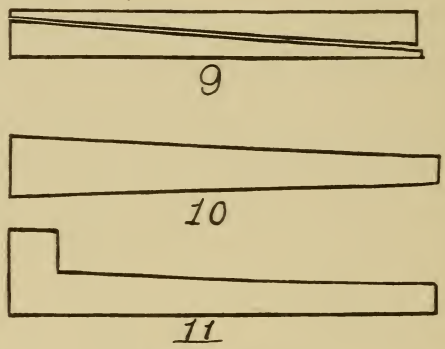


FIG. 9-10-11.

they divide. The twin-style of key is exhibited in Fig. 9. Usually the tapered sides are driven in from each end. The tapered square key is presented in Fig. 10 and is common in all machines, while the headed key, Fig. 11, is perhaps the most practical. It is seen in use frequently. The form is of the square pattern, somewhat flattened, and very slightly tapered, so as to increase the bite with each drive of

the hammer as the key is sent home in the key seat. The head affords a means by which the key can be withdrawn.

Referring next to the set screw problem, we find that set screws are more or less abused in every department, pretty much as the keys are. However, some of the forms of screw are incorrectly designed at the beginning. Fig. 12 is a style of set screw I

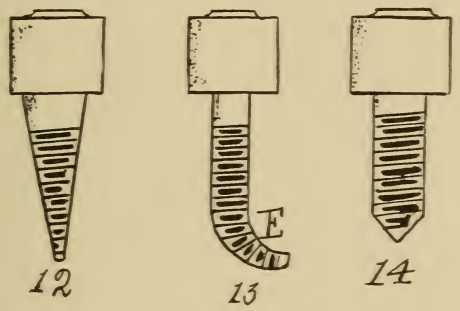


FIG. 12-13-14.

ran into in one place. It is made on the tapered plan and the threaded boring to receive it was similarly cut. Of course, the set screw could be turned in only just so far. The cap is held and the threaded bore in the base of the cap seat on the journal had to correspond perfectly to make the key a success. Still one sees samples of wrongfully treated set screws, a specimen of which is shown in Fig. 13 . Here is where through carelessness, the point of the set screw is bent over as at *E*. This is done in several ways. By permitting the set screw to remain too far out of its position, so that something contacts with the head

and bends the screw over. Or through carelessness in turning the screw with a heavy wrench. Pointed set screws as in Fig. 14 are not used in farming implements very often because the fatal point soon gouges out a groove or hole and the shaft is spoiled at that part. Simply a rounded point is desired. Set screws in collars with tightening nut are used freely.

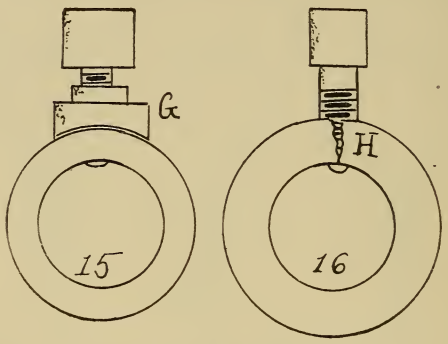


FIG. 15-16.

Fig. 15 is a sample of the same. The shoulder, *g*, instead of being a part of the collar, *h*, is a separate threaded nut like affair which is screwed on with the set screw and aids to hold it in position.

Collars designed on the plan presented in Fig, 16 are very liable to cause trouble by splitting when any undue strain is exerted at *h* by the pressure of the set screw. The only remedy is to substitute a new collar with shoulder at the set screw bore, or a heavier collar throughout. Concerning threads, one reason why set screws and nuts work loose is that the tendency is such in all threaded parts as exhibited in Fig. 17. The threaded parts, if allowed to rest one

upon the other as at *i*, without being secured, would work toward the end of the set screw or other threaded shaft in the direction of the arrow, caused by the jarring. To overcome this, the threaded part usually binds against something. This causes every

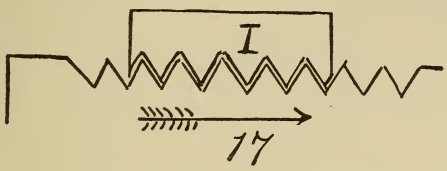


FIG. 17.

thread to press against its neighbor and a series of frictional bindings result and the parts hold fast. Among other forms of threads noticed by the writer in use in farming machinery and implements are the rather curious types shown in Figs. 18 and 19. Fig.

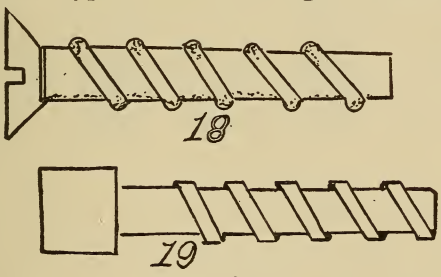


FIG. 18-19.

18 is a shaft on which there is a coil of raised threads, rounding in form, and arranged to fit into similarly grooved places in the seat into which the screw is to be turned. The thread of the screw in Fig 19 is not unusual and is employed where excessive strength is needed in the grip of the thread system of the set screw.

The Compensating Gear.

"There is no part of a traction engine gearing so essential, and yet so little understood," remarked the head of one of the oldest and best known of the thresher manufacturing concerns not long ago, "as the differential or compensating gear; and I very much doubt whether even all of our shop men engaged in assembling these gears have any very clear idea of the principles upon which they operate." Another prominent manufacturer says: "The compensating gear forms one of the greatest mechanical puzzles that was ever introduced, at one time, and it really never did find a place of utility until the traction engine was introduced."

We have no data to indicate just when the first compensating gear was attached to a self-propelling thresher engine; but since the compensating gear is much older than the farm traction, it is likely that the first traction engine made was equipped with this device. For one of the first difficulties to be overcome would be that incident to applying equal tractive force to a pair of drive wheels that must often of necessity turn at different speeds, as in turning corners or on uneven ground. The compensating gear does away with all difficulty from this source, and offers the most practical method of applying the power of one motor equally to both drive wheels,

regardless of their relative speed. How this is done we hope to make clear in what follows.

Perhaps the quickest way to arrive at an understanding of what happens when the compensating gear is in use is illustrated in Fig. 1, representing three pulleys loosely mounted on a shaft. If now we

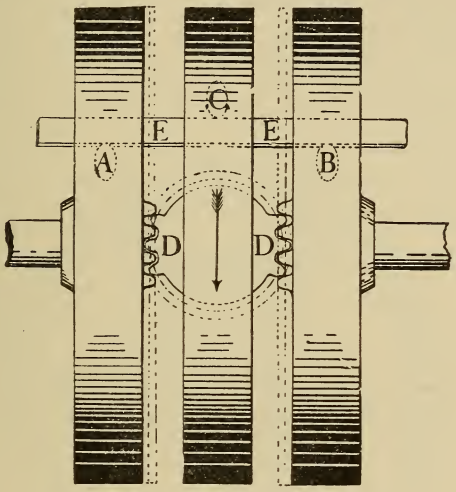


FIG. 1.

insert an iron bar between the spokes of all three, as at *E*, in Fig. 1, resting against spokes *A* and *B* of the outside pulleys which are equidistant from the central pulley, and turn the central pulley in the direction of the arrow so that the spoke *C* presses against the iron bar, it will turn both outside wheels with it so long as the resistance of each is the same. For the bar is nothing more than a lever, fulcrumed at *C*, and with equal weights at equal distances on each side of its fulcrum it cannot swing either way;

like having pound weights on each end of a scale; they will balance even. But if now we add even an ounce of additional weight to one side, that side will sink and the other end will rise. But that other end still exerts its pound of pressure on its end of the scale.

In the same way, if we take hold of pulley *A*, for instance, and retard its turning, the iron bar will exert the same pressure as before—no more—but since the pulley *A* is not turning as fast as *C* it follows that the bar can no longer keep its straight across position, but will swing on *C*, pushing *B* farther ahead until it (the bar) can no longer stay in position, but must drop out. The operation would be the same of course, although reversed, if we were to hold back pulley *B* instead of *A*. So long as the resistance of the outside pulleys remains the same, the center one with its bar interposed between the spokes would turn them indefinitely. But as soon as for any cause one of them offered more resistance to the pressure of the bar than the other, then, though pushing with equal force on both pulleys, the bar would move the one offering the least resistance the fastest, itself swinging till it could no longer keep its position btweeen the spokes.

Now let us substitute for the iron bar an iron cog wheel having one of the spokes of the central pulley for its shaft or axle, and meshing with cogs placed on the inner rim of each of the outside pulleys, as at *D*, Fig. 1. It will readily be seen that the opposite teeth of

the cog wheel, with the metal of the wheel between them, constitute a lever that, engaging with the teeth on the rims of the outer pulleys, works in exactly the same way that the bar *E* did in the first instance; excepting that when the cog wheel turns, the following teeth, as they engage with the outer pulley rims, form new levers to take the place of the ones just swinging out of mesh. But as long as the resistance of the outer pulleys is the same, the cog wheel cannot

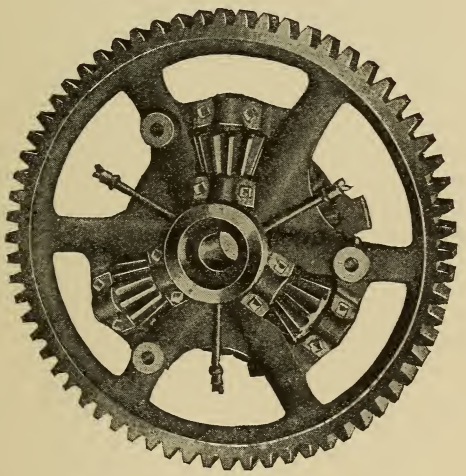
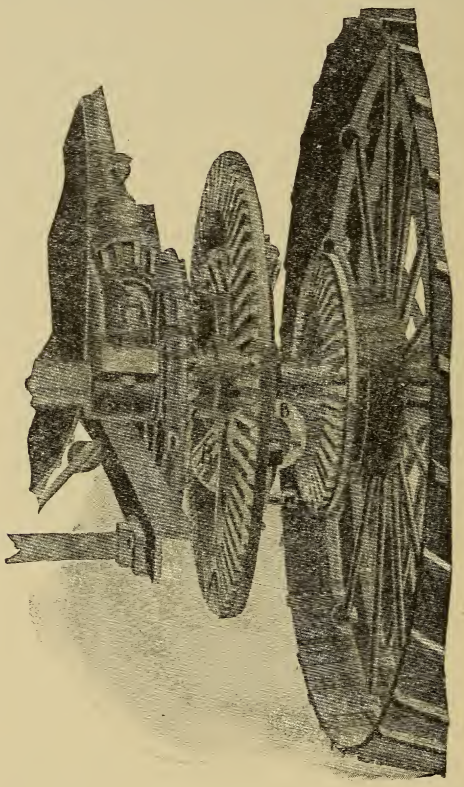


FIG. 2.

turn any more than the bar could, and for the same reason. Put three of these cogged gears, the usual number in this pattern of gear, and they are usually beveled, see Fig. 2, which is the driving wheel in an Advance differential gear, and you have a typical central wheel of a compensating gear. Provide suitable bevel gear wheels to mesh on each

side of this to be driven by it, and you have the compensating gear complete as usually applied to traction engines. Fig. 3, which shows the Aultman-Taylor gear opened up,



shows very clearly how the parts fit together. *A* is the central driving wheel, which is driven by a bevel gear instead of the usual intermediate wheel. *B B B* are the beveled cogs mounted in its spokes, and *C* and *D* are the wheels with which *B B B* mesh. The gear *D* is rigidly fastened to the main driving axle

and turns it, and the opposite drive wheel with it. The other drive wheel, part of which is shown in the figure, moves freely on the drive axle, and has the opposite gear wheel, *C,* firmly attached to it. So that both drive wheels are as free of each other as the pulleys in Fig. 1, but both receive exactly the

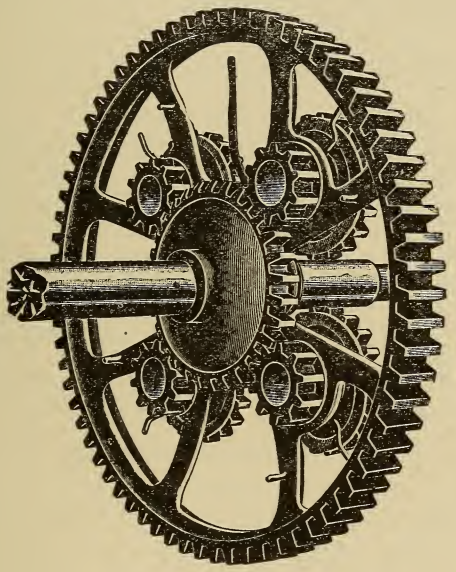


FIG. 4.

same "pull" from the engine through *A* and *B,* as already explained by Fig. 1.

For automobile work exactly the same principle is employed, but its application is somewhat different. With even the best made bevel gears there is danger of end thrust and excessive wear on the ends which, though not likely to give trouble in the slow moving traction engine, would speedily develop looseness

and rattling in the high speed motor vehicle. In order to avoid these difficulties spur gears were invented and are very popular with automobile builders. The driven wheels are gear wheels meshing with pinions attached to the sprocket pulley. Instead of being beveled, however, these pinions are cylindrical and arranged in geared pairs, with the axes parallel with the sprocket shaft. The pinions of each pair are set alternately on one or the other side of the sprocket, meshing with one another for about half their length, the remainder of each meshing with either of the axle gears, one of which is an internal gear, the others a regular spur wheel. When the vehicle is turning, one wheel revolves less rapidly, causing the pinion with which it is geared to revolve on its mate, which in turn revolves on its own axis, although still engaging the opposite and moving wheel of the vehicle. Fig. 4, which shows the driving or "sprocket" wheel of the Geiser compensating gear, shows this form as adapted to traction engine use. This, however, does not exhibit the fine workmanship and exact fitting necessary for high speed running that is exemplified in a well made automobile compensating gear; which is a beautiful bit of mechanism, as highly finished and as accurately fitted as the movement of a watch.

Engine Horse Power.

All calculations to find the horse power of an engine are necessarily approximate, as they are modified more or less by the factors of friction in the moving parts, loss of steam at the joints and valves, condensation, quality of lubrications, amount of load, etc.

The unit of power is the horse power, and was first calculated by Watt, that prince of inventors in steam enginery; and after numerous experiments Watt estimated the power of a good, average draught horse to be that which could lift 33,000 lbs. one foot high in a minute, 550 lbs. in one second, or 1,980,000 lbs. in an hour. Hence we have the horse power factor, 33,000 lbs.

Rules to find the horse power of an engine.

Problem.—What is the horse power of an engine whose piston is 12 inches in diameter, stroke 16 inches, revolutions 140 per minute, mean steam pressure 30 lbs. per square inch on piston?

Rule 1.—Multiply the area of piston in square inches by the mean pressure per square inch on the piston, then multiply this product by the speed of the piston in feet per minute, then divide this last product by 33,000 foot pounds per horse power.

Example.—Diameter of piston 12 inches. Mul-

tiply by itself $12 \times 12 = 144$ square inches of piston. Reduce this to square inches of *area* by multiplying $144 \times .7854 (^{7854}/_{10000}) = 113.0976$ square inches of area, then multiply this by mean pressure on piston, 30 lbs., $113.0976 \times 30 = 3392.928$ lbs. total pressure on piston, then multiply this product by speed of piston, 373.3 feet per minute = 1266580.-0224. Now divide this by 33,000 foot pounds per horse power = 38.3 horse power which this engine will generate with the steam pressure and speed given.

Rule 2.—Multiply the square of piston's diameter in inches by stroke in inches. Multiply resultant by revolutions per minute. Then multiply this product by 4. Now point off six figures from the right and multiply by the mean pressure in lbs., the final product is the horse power of an engine.

Example.—Square inches of piston's diameter is 144 × by stroke 16 inches = 2304. This × by revolutions per minute 140=322,560, resultant × by 4=1,290,240 which × by mean pressure 30 lbs.= 38.70 horse power of engine. This rule is correct within three-fourths of a horse power in 100.

Rule 3.—Multiply the square of piston's diameter in inches by mean pressure in lbs. Multiply the proruct by twice the stroke in feet. Multiply resultant by revolutions per minute. Then multiply this product by constant .0000238, the final resultant will be the horse power.

Example.—Square inches of piston 144 × by mean pressure 30=4,320×by twice the stroke in feet

2 2/3=11,520×by revolutions .140=161.2800× by constant .0000238=38.38 horse power of engine. The constant, .0000238, is found by dividing .7854 by 33,000 foot pounds.

Rule 4.—Multiply the area of piston by mean pressure. This product by the stroke in inches. Multiply resultant by 2. Again multiply by the revolutions per minute. Then divide product by 12, and divide final resultant by 33,000, the quotient will be the horse power of engine.

Example.—Area of piston 113.0976×by mean pressure 30=3392.9280×by stroke 16 inches=54286.8480×by 2=108573.6960×by revolutions per minute, 140=15200317.4400÷by 12=1266693-.1200÷by 33,000=38.38 h. p. of engine. In the foregoing rules no allowance is made for the piston rod, which, if so accounted for, would slightly reduce the horse power in each example.

SHAFTING.

To find the horse power of a shaft, multiply the *cube* of its diameter in inches by the revolutions per minute, and divide product by 82 for steel or 110 for iron shafting.

Example.—Diameter of shaft, 2 inches; revolutions, 160; then, 2^3×160=1280÷82=15.6 horse power, or 2^3×160=1280÷110=11.6, horse power of iron shaft.

BELTING.

In Europe cog wheels are used to transmit power almost exclusively, but in America 99% of the pow-

er transmitted is by belting. Cog wheel transmission is *positive,* belting is *not,* because with every revolution of a pulley a portion of the power is lost; the loss varies with the condition of the belt, change of load, state of the atmosphere, etc. The power of a belt to transmit motion is derived from the friction *hold* on the pulley; this is governed by the pressure or tension; a safe maximum working tension is about 45lbs. per inch in width. No dogmatic rule

Table of Horse Power for single belts, pulleys running 200 revolutions per minute, diameter of both pulleys being equal.

Diam. of Pulley, in.	WIDTH OF BELT IN INCHES.								Diam. of Pulley, in	WIDTH OF BELT IN INCHES.							
	1 H.P.	2 H.P.	2½ H.P.	3 H.P.	3½ H.P.	4 H.P	5 H.P.	6 H.P.		4 H.P.	5 H.P.	6 H.P.	8 H.P.	10 H.P.	12 H.P	14 H.P.	16 H.P.
6	44	.88	1.08	1.30	1.52	1.76	2.18	2.62	34	9.8	12.4	14.8	19.8	24.8	34.6	34.6	39.6
7	.51	1.02	1.28	1.53	1.79	2.04	2.54	3.06	36	10.4	13.0	15.6	21.0	26.2	31.4	36.6	41.8
8	.58	1.16	1.46	1.74	2.03	2.32	2.90	3.50	38	11.0	13.8	16.6	22.0	27.6	33.2	38.6	44.2
9	.65	1.30	1.64	1.95	2.27	2.60	3.28	3.94	40	11.6	14.6	17.4	23.2	29.2	35.0	40.8	46.6
10	.73	1.46	1.82	2.19	2.55	2.92	3.62	4.36	42	12.2	15.2	18.4	24.4	30.6	36.4	42.8	48.6
12	.87	1.74	2.18	2.61	3.04	3 48	4.36	5.24	44	12.8	16.0	19.2	25.6	32.0	38.4	44.8	51.2
14	1.02	2.04	2.54	3.06	3.57	4.08	5.06	6.10	46	13.4	16.8	20.0	26.8	33.2	40.2	46.8	53.6
16	1.16	2.32	2.90	3.48	4.06	4.64	5.82	6 96	48	14.0	17.6	20.8	28.0	34.8	42.0	48.8	56.0
18	1.31	2.62	3.28	3.93	4.58	5.24	6.54	7.84	50	14.4	18.0	21.8	29.2	36.4	43.6	50.8	58.0
20	1.45	2.90	3.64	4.35	5.07	5.80	7.28	8.72	54	15.6	19.6	23.6	31.2	39.2	47.2	52.8	62.4
22	1.60	3.20	4.80	4.80	5 60	6.40	8.00	9.60	60	17.6	21.6	26.2	34.8	43.6	52.4	61.6	69.6
24	1.74	3.48	5.22	5.22	6.09	7.00	8.08	10.4	66	19 2	24.0	28.8	38.4	48.0	57.6	67.2	76.8
26	1.90	3.80	5.70	5.70	6.65	7.60	9.40	11.4	72	20.8	26.0	31.2	42.0	52.4	62.8	73.2	83.6
28	2.04	4.08	6.12	6.12	7.14	8.20	1.02	12.2	78	22.8	28.4	34.0	45.2	56.8	68.0	79.6	90.8
30	2.18	4.36	6.54	6.54	7.63	8.80	10.8	13.6	84	24.4	30.8	38.8	48.8	61.2	72.8	85.6	97.2
32	2.32	4.64	6 96	6.96	8.12	9.40	11.6	14.0	96	27.6	34.6	48.4	56.0	70.0	82.4	97.6	110.

can be laid down to determine the efficiency of a belt. After a series of numerous experiments, Joshua Rose (modern machine shop practice) states that belts vary from 25 to 100 per cent. in efficiency, for reasons given above. A long belt will transmit more power than a short one of same width and tension. Consequently long belts are always the best if it is possible to use them. A 1-inch belt traveling 800 feet per minute and with proper tension will

transmit 1 h. p. If the same belt travels 1,600 feet the power will be doubled. Each additional inch to the width will add 1 h. p., at same speed and tension. A belt under good conditions will deliver 97 per cent. of its efficiency. If belts are too tight there will be quite a loss from friction of the journals, etc; if too loose, there will be still more loss from slipping. Excessive slipping also dries out the leather and reduces the adhesion. Within reasonable limits the greater the speed the more efficient a belt will be. About 3,750 feet per minute seems to be the maximum. A double belt will last longer than a single one, and will take double the tension, and will transmit 7/10 more power, as capacity to transmit power is governed by the frictional width of belt and its *pulling* strength. A rawhide belt will transmit from 25 to 50 per cent. more power than a tanned one, and for straight *non-* shifting work is much the most economical, but it is not adapted to cone pulleys or counter shaft work. Belts should be used with the hair side to the pulley. If pulleys are covered with leather there will be a gain of 25 per cent. in wear of belt and in power transmitted.

It is best to have the belts run off from the main shaft in *opposite* directions, to equalize the strain on the bearings. Let the diameter of the pulleys be as large as possible, within the maximum belt speed (3,750 feet per minute,) and a belt should never be *overworked,* and the tension should be such as will give a slight sag when in motion. The per cent. of power lost by shaft journal friction should not exceed

20 per cent. of the full load; if it does it may be charged to *tight* belting. The breaking strength of good leather belting per inch in width is the *solid leather,* 675 lbs.; at *rivet holes,* 362 lbs.; at *lacing holes,* 200 lbs. It will be seen, therefore, that belts would be far more durable if lacing could be done away with, as is being done in some establishments, the ends og belts being lapped and *cemented,* thus making the joints as strong as the body of the belt.

TO FIND THE LENGTH OF BELT WANTED.

Rule 1. Add the diameter of both pulleys, divide by 2, and multiply quotient by 3¼; add this product to twice the distance in inches between the centers of the shafts, and the final sum will be the length required. *Example.* Diameter of large pulley, 24 in. +12, diameter of small pulley=36÷2=18×3¼=58½+216, twice distance between shafts=274½ in. length required.

TO FIND WIDTH OF BELT REQUIRED FOR A GIVEN H. P.

Rule 2. Multiply the horse power by the constant 2,750, then multiply the diameter of driven pulley by the number of revolutions, and divide the first product by the latter, the quotient will be the width of belt required. *Example 2.* Horse power, 28×constant 2,750=77,000; diameter of pulley, 36 in.× revolutions 200=7,200; 77,000÷7,200=10.7 inches, width required.

TO FIND THE HORSE POWER WHICH A BELT WILL TRANSMIT.

Rule 3. Multiply the width of belt by diameter of driven pulley in inches, multiply this product by revolutions of pulley per minute, then divide final product by constant 2,750, the quotient will be the horse power. *Example* 3. Belt 10 in.×36 diameter of pulley =360×200 revolutions =72,000÷2,750 constant =26.5 h. p. required.

THE HORSE POWER AND WIDTH OF BELT GIVEN, FIND THE DIAMETER OF DRIVEN PULLEY REQUIRED.

Rule 4. Multiply the horse power by constant 2,750, now multiply revolutions of pulley by the width of belt, then divide the first product by the latter, the quotient will be the diameter wanted. *Example* 4. Horse power 28 × 2,750 = 77,000; revolutions 200×10=2,000; 77,000÷2,000=38.5, diameter wanted.

THE HORSE POWER, DIAMETER OF PULLEY AND WIDTH OF BELT GIVEN, FIND THE NUMBER OF REVOLUTIONS OF DRIVEN PULLEY.

Rule 5. Multiply the horse power by 2,750, now multiply the diameter of pulley by the width of belt, and then divide the first product by the latter. *Example* 5. Horse power 28 × 2,750 = 77,000; diameter 36 × 10 width = 360; 77,000 ÷360 = 211.4 revolutions wanted.

The above rules assume that the driving and driv-

en pulleys are of equal diameter, and the contact of belt half the circumference. If pulleys are of different diameter and contact of belt is less than half of circumference, then the rules must be modified as per tables below of areas of contact.

TABLE OF BELT CONTACTS.

Degrees of contact.	Fraction of contact	Dec. fraction of circumf.	Ratio.	Constant—Single Belt.	Double belt.
90° or	¼=	.25	2.21	6080	4250
112° "	5/16=	.312	1.72	4730	3310
120° "	1/3=	.333	1.6	4400	3080
135° "	⅜=	.375	1.4	3850	2700
150° "	5/12=	.417	1.24	3410	2390
165° "	7/16=	.437	1.17	3220	2250
180° "	½=	.500	1	2750	1925

For all practical purposes, the arc of contact of belt on smaller pulley can be roughly estimated by comparison with figures in first column in table above. For example, take arc of contact 150° and compare it with your belt. If it agrees approximately, then taking Rule 3 we have example 3 modified as follows: Belt 10×36=360×200=72,000÷ by *new* constant 3,410=21.1 horse power, or a loss of 5.4 horse power as compared with full contact or half circumference in Example 3.

OTHER RULES FOR FINDING SPEED AND SIZE OF PULLEYS.

To find size of driving pulley, multiply the diameter of driven by revolutions it should make, and divide the product by revolutions of driver. *Example* 1. Diameter of driven 12 inches; revolutions, 240; revolutions of driver, 160; then 12×240 = 2880 ÷ 160 = 18, diameter of driver wanted.

TO FIND THE SIZE OF DRIVEN PULLEY.

Multiply diameter of driver by its revolutions, and divide the product by revolutions of driven. *Example* 2. Diameter of driver, 18; revolutions, 160; revolutions of driven, 240; then, $18 \times 160 = 2{,}880 \div 240 = 12$ inches, diameter of driven.

TO FIND THE NUMBER OF REVOLUTIONS OF DRIVEN.

Multiply diameter of driver by its revolutions, and divide product by diameter of driven. *Example.* Diameter of driver, 18; revolutions, 160; diameter of driven, 12 inches; then $18 \times 160 = 2{,}880 \div 12 = 240$, revolutions of driven wanted.

TO FIND THE HORSE POWER OF A DRIVING PULLEY.

Multiply the circumference of pulley by the revolutions, and this product by width of belt, and divide final product by 600. *Example.* Circumference of pulley, 56.55; revolutions, 160; width of belt, 6 in.; then $56.55 \times 160 = 9048 \times 6 = 54{,}288 \div 600 = 9.04$, horse power of pulley wanted.

To find the circumference and area of any diameter *greater* than any in the above table. *Rule.*—Multiply any diameter given above by the factor 2, 3, 4, or 5, etc., the product of which will be the diameter whose circumference and area is wanted. *Example.*—What is the circumference of 140? Tabular diameter of $35 \times 4 = 140$. Tabular circumference of $35 = 109.9 \times 4 = 439.6$, circumference wanted. *Rule for the Area.*—Multiply the tabular area of tabular

diameter by the *square* of the factor. *Example.*—What is the area of 140? Tabular area of 35=962 .11×16(16 is the square of the factor 4)=15,393.76, area wanted.

The Circle.—The circumference of a circle is equal to the diameter multiplied by 3.1416. The area of a circle is equal to the square of the diameter multiplied by .7854.

Table of Diameter, Area and Circumference of Circles.

Diam.	Area.	Cir.	Diam.	Area.	Cir.	Diam.	Area.	Cir.
⅛	0.0123	.3927	16	201.06	50.26	54	2290.2	169.6
¼	0.0491	.7854	½	213.82	51.83	55	2375.8	172.8
⅜	0.1104	1.178	17	226.98	53.40	56	2463.0	175.9
½	0.1963	1.571	½	240.53	54.98	57	2551.8	179.1
⅝	0.3068	1.963	18	254.47	56.55	58	2642.1	182.2
¾	0.4418	2.356	½	268.80	58.12	59	2734.0	185.3
⅞	0.6013	2.741	19	283.53	59.69	60	2827.4	188.5
1	0.7854	3 142	½	298.65	61.26	61	2922.5	191.6
⅛	0.9940	3.534	20	314.16	62.83	62	3019 1	194.8
¼	1.227	3.927	½	330.06	64.40	63	3117.2	197.9
⅜	1.485	4.319	21	346.36	65.97	64	3217.0	201.0
½	1.767	4.712	½	363.05	67.54	65	3318.3	204.2
⅝	2.074	5.105	22	380.13	69.11	66	3421.2	207.3
¾	2.405	5.498	½	397.61	70.68	67	3525.7	210.5
⅞	2 761	5.890	23	415.48	72.25	68	3631.7	213.6
2	3.142	6.283	½	433.73	73.83	69	3739.3	216.7
¼	3.976	7.068	24	452.39	75.40	70	3848.5	219.9
½	4.909	7.854	½	471.43	76.97	71	3959.2	223.0
¾	5.939	8.639	25	490.87	78.54	72	4071.5	226.2
3	7.068	9.425	26	530.93	81.68	73	4185.4	229.3
¼	8.296	10.21	27	572.56	84.82	74	4300.8	232.5
½	9.621	10.99	28	615.75	87.96	75	4417.9	235.6
¾	11.044	11.78	29	660.52	91.10	76	4536.5	238.7
4	12.566	12.56	30	706.86	94.25	77	4656.7	241.9
½	15.904	14.14	31	754.77	97.39	78	4778.4	245.0
5	19.635	15.71	32	804.25	100.5	79	4901.7	248.2
½	23.758	17.23	33	855.30	103.6	80	5026.6	251.3
6	28.274	18.85	34	907.92	106.8	81	5153.0	254.5
½	33.183	20.42	35	962.11	109.9	82	5281.0	257.6
7	38.484	21.99	36	1017.9	113.1	83	5410.6	260.7
½	44.179	23.56	37	1075.2	116.2	84	5541.8	263.9
8	50.265	25.13	38	1134.1	119.4	85	5674.5	267.0
½	56.745	26.70	39	1194.6	122.5	86	5808.8	270.2
9	63.617	28.27	40	1256.6	125.6	87	5944.7	273.3
½	70.882	29.84	41	1320.2	128.8	88	6082.1	276.4
10	78.54	31.41	42	1385.4	131.9	89	6221.1	279.6
½	86.59	32.98	43	1452.2	135.1	90	6361.7	282.7
11	95.03	34.55	44	1520.5	138.2	91	6503.9	285.9
½	103.87	36.13	45	1590.4	141.4	92	6647.6	289.0
12	113.10	37.70	46	1661.9	144.5	93	6792.9	292.2
½	122.72	39.27	47	1734.9	147.6	94	6939.8	295.3
13	132.73	40.84	48	1809.6	150.8	95	7088.2	298.4
½	143.14	42.41	49	1885.7	153.9	96	7238.2	301.6
14	153.94	43.98	50	1963.5	157.1	97	7389.8	304.7
½	165.13	45.55	51	2042.8	160.2	98	7543.0	307.9
15	176.71	47.12	52	2123.7	163.3	99	7697.7	311.0
½	188.69	48.69	53	2206.2	166.5	100	7854.0	314.2

THE PROPERTIES OF SATURATED STEAM.

Pressure above Vacuum in Pounds per Square Inch.	Temperature, Fahrenheit Degrees.	Quantities of Heat in British Thermal Units.			Weight of a Cubic Foot of Steam in Pounds.	Volume.	
		Required to Raise Temperature of the Water from 32° to $t°$.	Total Latent Heat at Pressure p.	Total Heat above 32°.		Of a Pound of Steam in Cubic Feet.	Ratio of Vol. of Steam to Vol. of Eq. Weight of Dist. Water at Temp. of Maximum Density.
1	2	3	4	5	6	7	8
p	t	q	L	H	W	V	R
1	102.018	70.040	1043.015	1113.055	.003027	330.4	20623
2	126.302	94.368	1026.094	1120.462	.005818	171.9	10730
3	141.654	109.764	1015.380	1125.144	.008522	117.3	7325
4	153.122	121.271	1007.370	1128.641	.011172	89.51	5588
5	162.370	130.563	1000.899	1131.462	.013781	72.56	4530
6	170.173	138.401	995.441	1133.842	.016357	61.14	3816
7	176.945	145.213	990.695	1135.908	.018908	52.89	3302
8	182.952	151.255	986.485	1137.740	.021436	46.65	2912
9	188.357	156.699	982.690	1139.389	.023944	41.77	2607
10	193.284	161.660	979.232	1140.892	.026437	37.83	2361
11	197.814	166.225	976.050	1142.275	.028911	34.59	2159
12	202.012	170.457	973.098	1143.555	.031376	31.87	1990
13	205.929	174.402	970.346	1144.748	.033828	29.56	1845
14	209.604	178.112	967.757	1145.869	.036265	27.58	1721
14.69	212.000	180.531	966.069	1146.600	.037928	26.37	1646
15	213.067	181.608	965.318	1146.926	.038688	25.85	1614
16	216.347	184.919	963.007	1147.926	.041109	24.33	1519
17	219.452	188.056	960.818	1148.874	.043519	22.98	1434
18	222.424	191.058	958.721	1149.779	.045920	21.78	1359
19	225.255	193.918	956.725	1150.643	.048312	20.70	1292

THE PROPERTIES OF SATURATED STEAM

1	2	3	4	5	6	7	8
p	*t*	*q*	*L*	*H*	*W*	*V*	*R*
20	227.964	196.655	954.814	1151.469	.050696	19.73	1231.0
22	233.069	201.817	951.209	1153.026	.055446	18.04	1126.0
24	237.803	206.610	947.861	1154.471	.060171	16.62	1038.0
26	242.225	211.089	944.730	1155.819	.064870	15.42	962.3
28	246.376	215.293	941.791	1157.084	.069545	14.38	897.6
30	250.293	219.261	939.019	1158.280	.074201	13.48	841.3
32	254.002	223.021	936.389	1159.410	.078839	12.68	791.8
34	257.523	226.594	933.891	1160.485	.083461	11.98	748.0
36	260.883	230.001	931.508	1161.509	.088067	11.36	708.8
38	264.093	233.261	929.227	1162.488	.092657	10.79	673.7
40	267.168	236.386	927.040	1163.426	.097231	10.28	642.0
42	270.122	239.389	924.940	1164.329	.101794	9.826	613.3
44	272.965	242.275	922.919	1165.194	.106345	9.403	587.0
46	275.704	245.061	920.968	1166.029	.110884	9.018	563.0
48	278.348	247.752	919.084	1166.836	.115411	8.665	540.9
50	280.904	250.355	917.260	1167.615	.119927	8.338	520.5
52	283.381	252.875	915.494	1168.369	.124433	8.037	501.7
54	285.781	255.321	913.781	1169.102	.128928	7.756	484.2
56	288.111	257.695	912.118	1169.813	.133414	7.496	467.9
58	290.374	260.002	910.501	1170.503	.137892	7.252	452.7
60	292.575	262.248	908.928	1171.176	.142362	7.024	438.5
62	294.717	264.433	907.396	1171.829	.146824	6.811	425.2
64	296.805	266.566	905.900	1172.466	.151277	6.610	412.6
66	298.842	268.644	904.443	1173.087	.155721	6.422	400.8
68	300.831	270.674	903.020	1173.694	.160157	6.244	389.8
70	302.774	272.657	901.629	1174.286	.164584	6.076	379.3
72	304.669	274.597	900.269	1174.866	.169003	5.917	369.4
74	306.526	276.493	898.938	1175.431	.173417	5.767	360.0
76	308.344	278.350	897.635	1175.985	.177825	5.624	351.1
78	310.123	280.170	896.359	1176.529	.182229	5.488	342.6
80	311.866	281.952	895.108	1177.060	.186627	5.358	334.5
82	313.576	283.701	893.879	1177.580	.191017	5.235	326.8
84	315.250	285.414	892.677	1178.091	.195401	5.118	319.5
86	316.893	287.096	891.496	1178.592	.199781	5.006	312.5
88	318.510	288.750	890.335	1179.085	.204155	4.898	305.8

THE PROPERTIES OF SATURATED STEAM

1	2	3	4	5	6	7	8
p	*t*	*q*	*L*	*H*	*W*	*V*	*R*
90	320.094	290.373	889.196	1179.569	.208525	4.796	299.4
92	321.653	291.970	888.075	1180.045	.212892	4.697	293.2
94	323.183	293.539	886.972	1180.511	.217253	4.603	287.3
96	324.688	295.083	885.887	1180.970	.221604	4.513	281.7
98	326.169	296.601	884.821	1181.422	.225950	4.426	276.3
100	327.625	298.093	883.773	1181.866	.230293	4.342	271.1
105	331.169	301.731	881.214	1182.945	.241139	4.147	258.9
110	334.582	305.242	878.744	1183.986	.251947	3.969	247.8
115	337.874	308.621	876.371	1184.992	.262732	3.806	237.6
120	341.058	311.885	874.076	1185.961	.273500	3.656	228.3
125	344.136	315.051	871.848	1186.899	.284243	3.518	219.6
130	347.121	318.121	869.688	1187.809	.294961	3.390	211.6
135	350.015	321.105	867.590	1188.695	.305659	3.272	204.2
140	352.827	324.003	865.552	1189.555	.316338	3.161	197.3
145	355.562	326.823	863.567	1190.390	.326998	3.058	190.9
150	358.223	329.566	861.634	1191.200	.337643	2.962	184.9
160	363.346	334.850	857.912	1192.762	.358886	2.786	173.9
170	368.226	339.892	854.359	1194.251	.380071	2.631	164.3
180	372.886	344.708	850.963	1195.671	.401201	2.493	155.6
190	377.352	349.329	847.703	1197.032	.422280	2.368	147.8
200	381.636	353.766	844.573	1198.339	.443310	2.256	140.8
210	385.759	358.041	841.556	1199.597	.464295	2.154	134.5
220	389.736	362.168	838.642	1200.810	.485237	2.061	128.7
230	393.575	366.152	835.828	1201.980	.506139	1.976	123.3
240	397.285	370.008	833.103	1203.111	.527003	1.898	118.5
250	400.883	373.750	830.459	1204.209	.547831	1.825	114.0
260	404.370	377.377	827.896	1205.273	.568626	1.759	109.8
270	407.755	380.905	825.401	1206.306	.589390	1.697	105.9
280	411.048	384.337	822.973	1207.310	.610124	1.639	102.3
290	414.250	387.677	820.609	1208.286	.630829	1.585	99.0
300	417.371	390.933	818.305	1209.238	.651506	1.535	95.8

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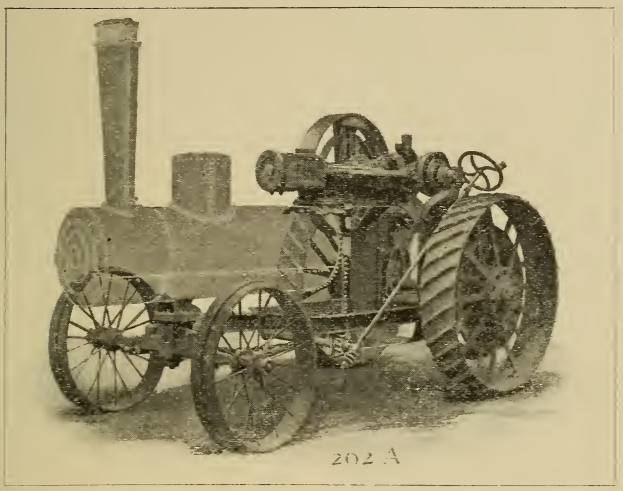
Eclipse Threshing Machinery



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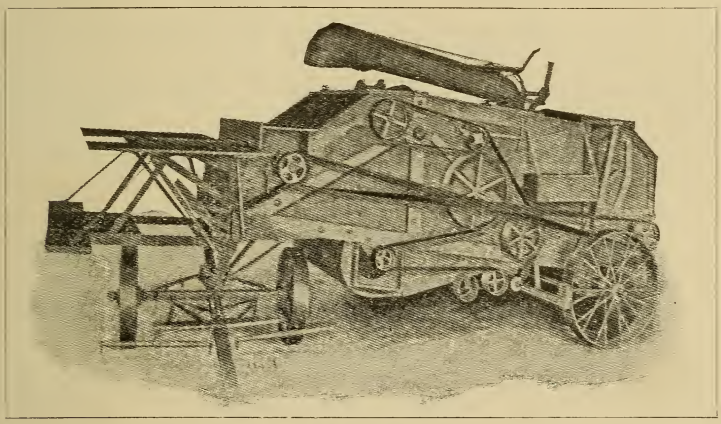

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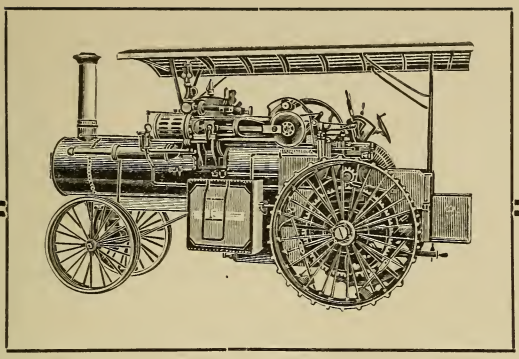

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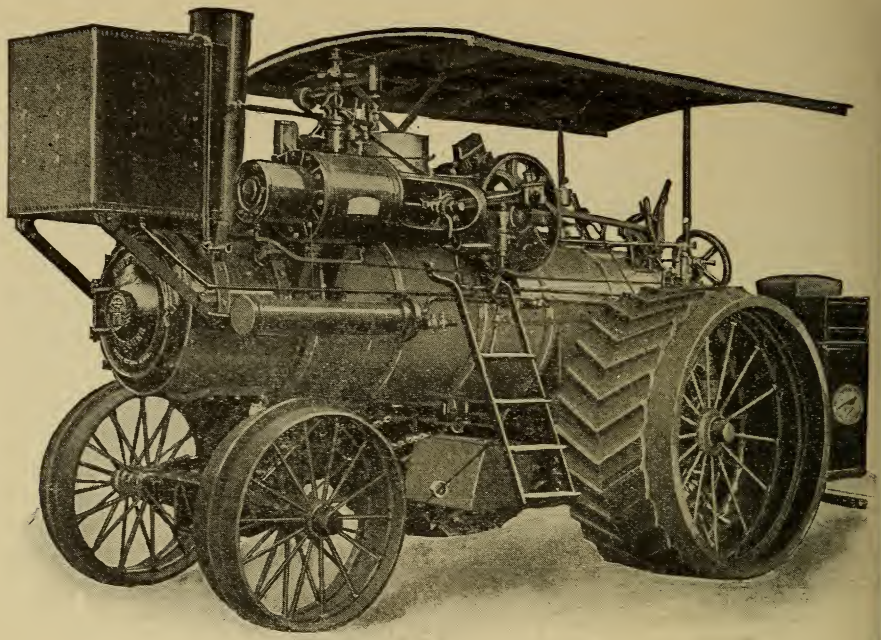

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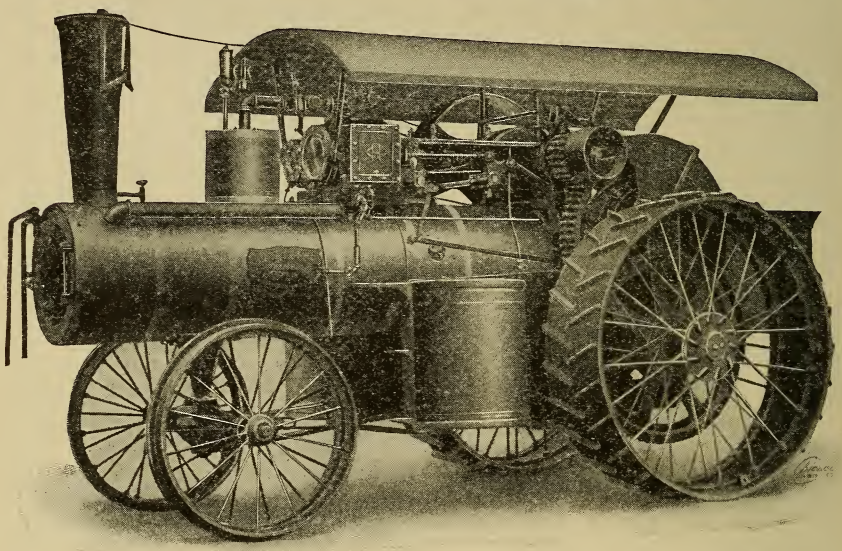

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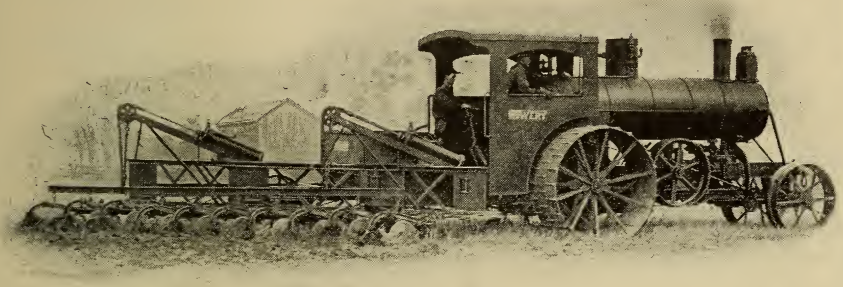

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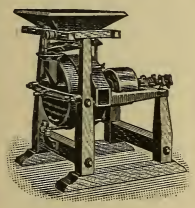

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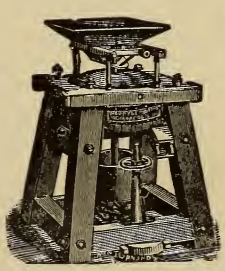

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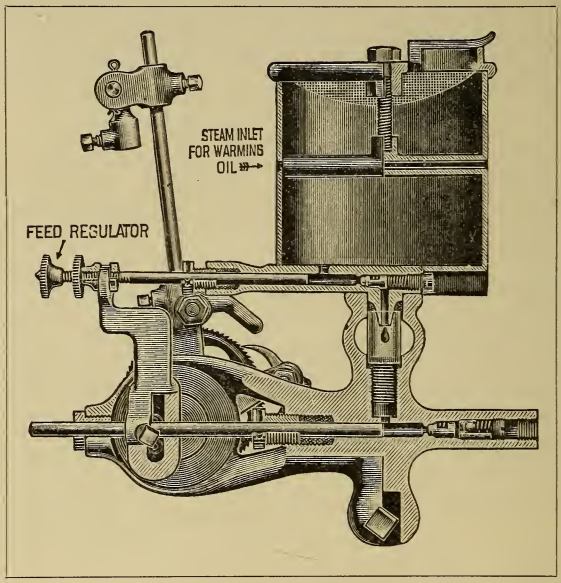

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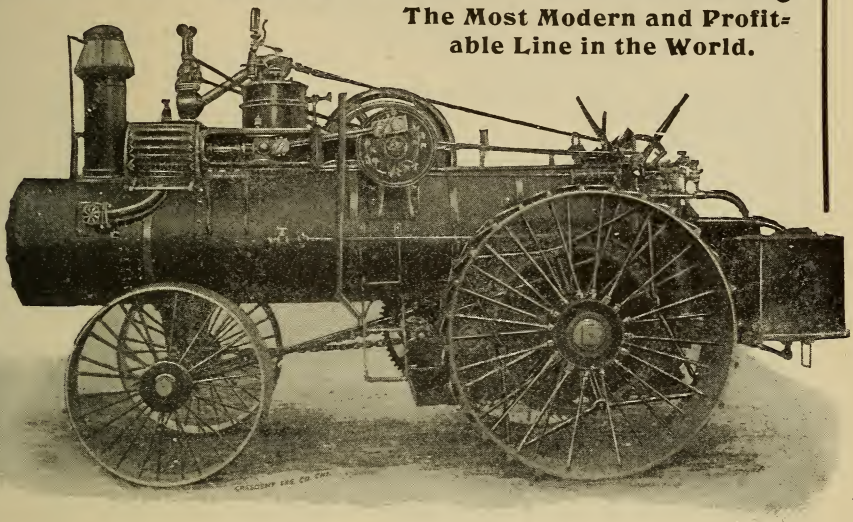

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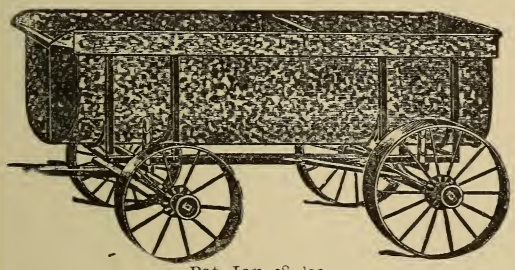

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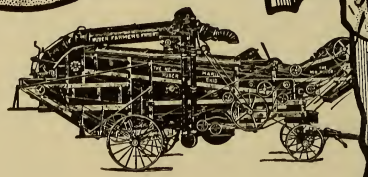

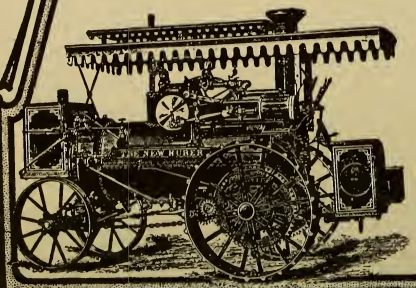

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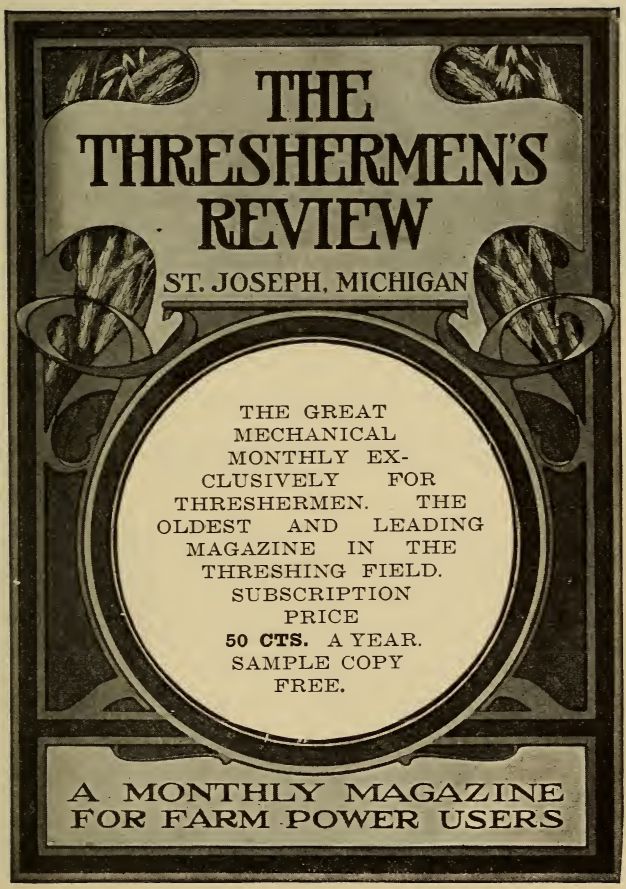
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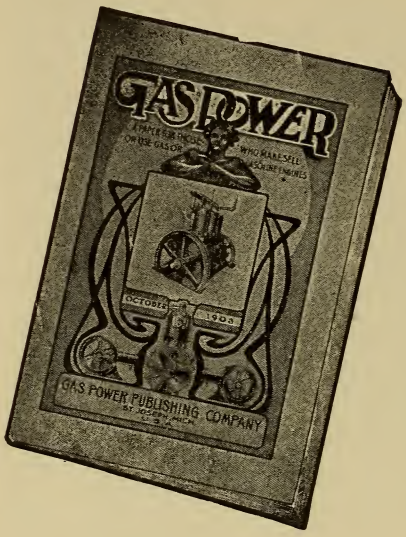

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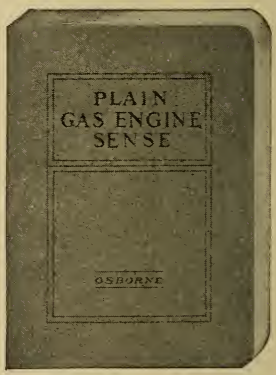

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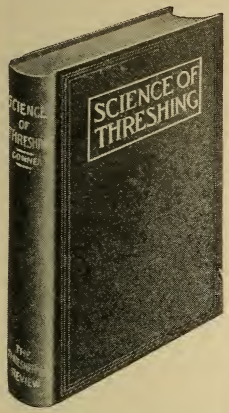

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